NOTICE INVITING TENDER

FOR

STEAM GENERATION PLANT AT TALCHER, ODISHA (INDIA)

(NIT NO : PNMM/PC-150/E- 4003/NCB)

TALCHER FERTILIZERS LIMITED

[A JOINT VENTURE OF M/s GAIL (INDIA) LIMITED (GAIL), M/s RASHTRIYA CHEMICALS & FERTILIZERS LTD. (RCF), M/s COAL INDIA LTD. (CIL), & M/s FERTILIZER CORPORATION OF INDIA LTD (FCIL)]

ISSUED BY

PDIL

PROJECTS & DEVELOPMENT INDIA LTD.
(A Govt. Of India Enterprise)
PDIL BHAWAN, A-14, Sector-1,
NOIDA U.P. (India)

07.02.2020
## PART-I, COMMERCIAL

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SECTION-I

INVITATION FOR BID (IFB)
SECTION-I
“INVITATION FOR BID (IFB)”

Ref No: PNMM/PC150/E-4003/NCB 07.02.2020

To,

PROSPECTIVE BIDDERS

SUB: TENDER DOCUMENT FOR STEAM GENERATION PLANT ALONG WITH ALL ASSOCIATED FACILITIES ON LSTK BASIS

Dear Sir/Madam,

1.0 INTRODUCTION:

1.1 GAIL (India) Limited (GAIL), Rashtriya Chemicals & Fertilizers Limited (RCF), Coal India Limited (CIL) and Fertilizer Corporation of India Limited (FCIL) have formed a Joint Venture company in the name of Talcher Fertilizers Limited (TFL) hereinafter also referred to as "Owner", intends to set up Steam generating Plant for its Coal gasification and Ammonia Urea Plant, an integrated fertilizer and chemical complex comprising of Coal Gasification and Gas Purification Unit, Ammonia Synthesis Unit, Urea Plant, along with necessary offsite and utility facilities, within the premises of existing closed coal based Ammonia-Urea Complex of Fertilizer Corporation of India Limited (FCIL) at Talcher Unit, Angul district, in the state of Odisha, India.

1.2 GAIL (India) Limited is a Public Sector Unit under the Ministry of Petroleum & Natural Gas and Rashtriya Chemicals & Fertilizers Limited (RCF) & Fertilizer Corporation of India Limited (FCIL) are two Public Sector Units under the Ministry of Chemicals & Fertilizers and Coal India Limited (CIL) is a Public Sector Unit under the Ministry of Coal, Govt. of India.

1.3 GAIL (India) Limited (GAIL), is India’s flagship Natural Gas Company, integrating all aspects of the Natural Gas value chain (including Exploration & Production, Processing, Transmission, Distribution and Marketing) and its related services. In a rapidly changing scenario, GAIL is spearheading the move to a new era of clean fuel industrialization, creating a quadrilateral of green energy corridors that connect major consumption centers in India with major gas fields, LNG terminals and other cross border gas sourcing points. GAIL is also expanding its business to become a player in the International Market.

1.4 Rashtriya Chemicals & Fertilizers Limited (RCF), a leading Public Sector Undertaking in the field of fertilizers, is engaged in manufacture and marketing of Fertilizers and Industrial chemicals. The company was carved out of the erstwhile Fertilizer Corporation of India Ltd at the time of reorganisation way back in the year 1978. Presently, Rashtriya Chemicals & Fertilizers Ltd. (RCF) is a leading fertilizer manufacturer in India having two production facilities, one at Trombay in Mumbai and the other at Thal in Alibag city which is 100 kilometers from Mumbai. Thal unit of RCF comprises Ammonia and Urea Plants and Trombay unit comprises Ammonia Urea Plants along with chemical plants like Methanol, Nitric Acid, Sulphuric Acid, Phosphoric Acid and Nitro Phosphate fertilizers of different composition.
1.5 **Coal India limited (CIL)** was formed in November, 1975 as a holding company to manage the coal mines nationalized in between 1971 to 1973. The company, with 78.86% of its equity owned by Government of India, is world’s largest hard coal producing company. It has core competence across the entire gamut of the coal business value chain. The business domain includes exploration, planning and design of mines, coal mining operations, coal beneficiation and marketing. CIL meets 42% of the nation’s primary energy demand and caters 81% of the nation’s coal requirement.

1.6 **Fertilizer Corporation of India Limited (FCIL)** is a Central Government undertaking under the administrative control of Ministry of Chemicals and Fertilizers. Due to non-viability of the operation of fertilizer unit, Government of India has decided to close the fertilizer plants. The net worth of the company has become negative and the corporation was referred to BIFR in April 1992 under the sick Industrial Companies (Special provision under Act 1985).

1.7 Projects and Development India Limited (PDIL), hereinafter referred to as CONSULTANT on behalf of M/s Talcher Fertilizers Ltd. (TFL), hereinafter referred as OWNER, has the pleasure of inviting eligible bidders to submit Bid ONLINE through Central Public Procurement (CPP) Portal in Single Stage Two Bid System, for the subject Project.

2.0 The brief details of the tender are as under:

<table>
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<tr>
<th>(A) NAME OF WORK / BRIEF SCOPE OF SERVICE/JOB</th>
<th>STEAM GENERATION PLANT ALONG WITH ALL ASSOCIATED FACILITIES ON LSTK BASIS</th>
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<td>(B) TENDER NO. &amp; DATE</td>
<td>PNMM/PC150/E-4003/NCB DATED 07.02.2020</td>
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<td>(C) TYPE OF BIDDING SYSTEM</td>
<td>SINGLE BID SYSTEM</td>
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<td>TWO BID SYSTEM</td>
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<td>(D) TYPE OF TENDER</td>
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<td>MANUAL</td>
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<td>(E) COMPLETION PERIOD</td>
<td>26 MONTHS (COMMISSIONING OF PLANT, RECKONED FROM DATE OF ISSUANCE OF FOA</td>
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<td>(F) BID SECURITY / EARNEST MONEY DEPOSIT (EMD)</td>
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<td>NOT APPLICABLE</td>
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Amount: INR 8.92 Crores

(Refer clause no.16 of ITB)
| (G) | AVAILABILITY OF TENDER DOCUMENT ON WEBSITE(S) | GAIL (www.gailtenders.in)  
RCF Ltd. (www.rcfltd.com)  
CIL (www.coalindia.in)  
CPP Portal (https://etenders.gov.in/eprocure/app)  
TFL (http://tflonline.co.in) |
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<td>(H)</td>
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| (I) | DATE, TIME & VENUE OF PRE-BID MEETING       | 27.02.2020 at 11:00 hrs. (IST)  
Venue:  
M/s Projects & Development India Limited  
P.D.I.L Bhawan, A-14, Sector-1,  
Noida, (PIN 201301)  
Dist. Gautam Budh Nagar (UP). (India) |
|     |                                             |                             |
| (J) | DUE DATE & TIME FOR BID SUBMISSION          | 07.04.2020 at 14.00 hrs. (IST) |
|     |                                             |                             |
| (K) | DATE, TIME & VENUE FOR UN-PRICED BID OPENING| 08.04.2020, at 14.00 hrs. (IST),  
Venue:  
M/s Projects & Development India Limited  
P.D.I.L Bhawan, A-14, Sector-1,  
Noida, (PIN 201301)  
Dist. Gautam Budh Nagar (UP). (India) |
|     |                                             |                             |
| (L) | Address for Communication                   |                             |
| (i) | PDIL                                        | M/s Projects & Development India Limited  
P.D.I.L Bhawan, A-14, Sector-1,  
Noida, (PIN 201301)  
Dist. Gautam Budh Nagar (UP). (India)  
Kind Attention:  
Mr. P.R. Sahu, Addl. General Manager (M.M)  
Fax no. : +91-120-2529801  
Tel no. : +91-120-2544063  
E-mail : prsahu@pdilin.com  
anjali@pdilin.com  
amal@pdilin.com |
| (ii) | TFL                                         | M/s Talcher Fertilizers Ltd. (TFL),  
C/O GAIL Training Institute,  
PARC Building,  
Plot No. 24, Sector-16A,  
Film City, Noida  
District – G.B. Nagar,  
U.P. - 201301  
Kind Attention : Mr. Amit Kumar Singh (General Manager)  
Tel No. : +91-120-2518349,  
+91-120-4097150/199  
E-mail : p_jana@gail.co.in  
ak.singh@gail.co.in  
sdasgupta@gail.co.in |
In case of the days specified above happens to be a holiday in TFL/PDIL, the next working day shall be implied.

3.0 Bids must be submitted strictly in accordance with Clause No. 11 of ITB depending upon Type of Tender as mentioned at Clause no. 2.0 (D) of IFB. The IFB is an integral and inseparable part of the bidding document.

4.0 The following documents in addition to uploading the bid on CPP Portal (https://etenders.gov.in/eprocure/app) shall also be submitted in Original (in physical form) within 7 (seven) days from the bid due date provided the scanned copies of the same have been uploaded on CPP Portal (https://etenders.gov.in/eprocure/app) by the bidder along with e-bid within the due date and time to the address mentioned in Clause no. 2.0 (M) of IFB:-

i) EMD/Bid Security  
ii) Power of Attorney  
iii) Pre-Signed Integrity Pact  
iv) Original Letter of TPI as per Appendix-I at Section-II

5.0 Bidder(s) are advised to quote strictly as per terms and conditions of the tender documents and not to stipulate any deviations/exceptions.

6.0 Any bidder, who meets the Bid Evaluation Criteria (BEC) and wishes to quote against this Tender Document, may download the complete Tender Document along with its amendment(s) if any from websites as mentioned at 2.0 (G) of IFB and submit their Bid complete in all respect as per terms & conditions of Tender Document on or before the Due Date & Time of Bid Submission.

7.0 Bid(s) received from bidders to whom tender/information regarding this Tender Document has been issued as well as offers received from the bidder(s) by downloading Tender Document from above mentioned website(s) shall be taken into...
consideration for evaluation & award provided that the Bidder is found responsive subject to provisions contained in Clause No. 2 of ITB.

The Tender Document calls for offers on single point “Sole Bidder” responsibility basis and in total compliance of Scope of Works as specified in Tender Document:

8.0 Any revision, clarification, corrigendum, time extension, etc. to this Tender Document will be hosted on the above mentioned website(s) only as per Clause No. 2.0 (G) of IFB. Bidders are requested to visit the website regularly to keep themselves updated.

9.0 All the bidders including those who are not willing to submit their bid are required to submit F-6 (Acknowledgement cum Consent letter) duly filled within 7 days from receipt of tender information.

10.0 The bidder shall submit the bid ONLINE through Central Public Procurement (CPP) Portal. Bids complete in all respects should be uploaded in the CPP portal on or before the Bid Due Date and time mentioned in at Sl No. 2(K) above. Bids through Post/ Fax / E-mail /CD/ any other mode other than that specified in ITB will not be accepted

11.0 TFL/PDIL reserves the right to reject any or all the bids received at its discretion without assigning any reason whatsoever.

This is not an Order.

Thanking You,

(Parab Sahu)
Addl. General Manager (M.M)
Projects & Development India Limited
Tel No. : +91-120-2544063
E-mail : prsahu@pdilin.com
SECTION-II

BID EVALUATION CRITERIA

&

EVALUATION METHODOLOGY
SECTION-II

A. **BID EVALUATION CRITERIA (BEC)**

Bids are hereby invited from competent domestic bidders meeting the technical and financial criteria of respective BEC stated hereunder.

Evaluation of Techno-Commercial offers shall be carried out for only those Bidders who shall meet the BEC.

Silent features of BEC and other terms and conditions are as given below:

1.0 **Technical Criteria:**

1.1. The Bidder should possess experience of having successfully executed the job of Design & Engineering, Procurement, Supply, Construction & Erection, Testing, Pre-commissioning, Commissioning Circulating Fluidized Bed combustion (CFBC) or Pulverized Coal (PC) type coal fired boiler of installed total capacity of minimum 280 TPH under single stream or multiple streams of minimum 140 TPH capacity each on Turnkey/ EPC basis, with steam parameters of minimum 107 Kg/cm²(g) pressure and 515°C Temperature at battery limit of Boiler, in the last 10 years reckoned from the bid due date. Further, the said plant should have been in satisfactory operation for a minimum period of one year from the date of Acceptance.

**Note:**

(a) **Eligibility criteria in case bid is submitted on the basis of technical experience of FOREIGN BASED ANOTHER COMPANY (SUPPORTING COMPANY) which holds more than fifty percent of the paid up share capital of the bidder company or vice versa:**

Offers of those bidders (not under consortium arrangement) who themselves do not meet the technical experience criteria as stipulated in the BEC and are quoting based on the experience of Foreign based another company (Supporting Company) can also be considered. In such case the supporting company should hold more than fifty percent of the paid up share capital of the bidding company or vice versa.

However, the supporting company should on its own meet the technical experience as stipulated in the BEC and should not rely on any other company or through any other arrangement like Technical collaboration agreement.

In that case as the bidding company is dependent upon the technical experience of another company with a view to ensure commitment and involvement of the companies involved for successful execution of the contract, the participating bidder should enclose the following Agreements/ Guarantees/ Undertakings along with the techno-commercial bid:

i. An Agreement (as per format enclosed at F-23) between the bidder and the supporting company.
ii. Guarantee (as per format enclosed at F-24) by the supporting company to TFL/PDIL for fulfilling the obligation under the Agreement.

iii. Undertaking by Supporting Company to provide a Performance Bank Guarantee (as per format and instructions enclosed at F-26), equivalent to 50% of the value of the PBG which is to be submitted by the bidding company, in case of being the successful bidder.

In cases where foreign based supporting company does not have Permanent Establishment in India as per Indian Income Tax Act, the bidding company can furnish Performance Bank Guarantee for an amount which is sum of PBG amount to be submitted by the bidder and additional PBG amount required to be submitted by the supporting company subject to the condition that supporting company have 100% paid up equity share capital of the bidder either directly or through intermediate subsidiaries or vice versa.

In such case bidding company shall furnish an undertaking that their foreign based supporting company is not having any Permanent Establishment in India in terms of Income Tax Act of India.

In case Supporting company fails to submit Bank Guarantee as per (c) above, EMD/SD submitted by the bidder shall be forfeited.

iv. Undertaking from the supporting company to the effect that in addition to invoking the PBG submitted by the bidding company, the PBG provided by supporting company shall be invoked by TFL due to non-performance of the bidding company.

Note: In case Supporting Company fails to submit Bank Guarantee as per (iii) above, EMD/ SD submitted by the bidder shall be forfeited.

However, the Financial BEC of tender is to be met by bidder on their own.

(b) Job executed by a Bidder for its own plant/ project cannot be considered as experience for the purpose of meeting BEC of the tender. However, jobs executed for Subsidiary/ Fellow subsidiary/ Holding company will be considered as experience for the purpose of meeting BEC subject to submission of tax paid invoice(s) duly certified by Statutory Auditor of the Bidder towards payments of statutory tax in support of the job executed for Subsidiary/ Fellow subsidiary/ Holding company. Such Bidders to submit these documents in addition to the documents specified to meet BEC.

(c) The bidder must submit the completion certificate/acceptance certificate issued by end user/ owner (or their consultant who has been duly authorized by them to issue such certificate) only after completion of work/ supply in all aspects.

(d) Only documents (Work order, completion certificate, execution certificate etc.) which have been referred /specified in the bid shall be considered in reply to the queries during evaluation of bids.

(e) In case more than one contract/order/agreement/DLOA are emanating against same tender, these contracts are to be considered as single contract for evaluation of credentials of a bidder for meeting their experience criteria.
2.0 Financial Criteria:

2.1 The Annual Turnover in any one of the last three (03) preceding financial years i.e. FY 2018-19/FY 2017-18/FY 2016-17 or calendar years 2018/2017/2016 of the bidder should be at least INR 243 Crore.

2.2 Net Worth of the Company should be positive as per last audited financial year (F.Y 2018-19 or calendar year 2018).

2.3 The Bidder should have minimum working capital equal to INR 48.60 Crore as per last audited financial year (F.Y. 2018-2019 or Calendar year 2018). However, if the bidder’s working capital is negative or inadequate, the bidder shall submit a letter from their Bank having Net worth of the bank not less than Rs. 100.0 Crores (or equivalent USD), confirming the availability of line of credit for INR 48.60 Crore. The line of credit from bank shall be submitted strictly as per prescribed format.

3.0 BEC for START-UPS:

The Technical and Financial BEC as stipulated above shall also be applicable for start-ups. However, the Startups are exempted from submission of EMD. For availing the relaxation of EMD, bidder is required to submit requisite certificate towards Startup enterprise registration issued by Department of Industrial Policy and Promotion, Ministry of Commerce & Industry and the certificate should be certified by the Chartered Accountant (not being an employee or a Director or not having any interest in the bidder’s company/firm) and notary public with legible stamp.

4.0 DOCUMENTS TO BE SUBMITTED FOR COMPLIANCE TO ‘BEC’

(i) Technical Criteria of BEC:

To meet the criteria (1.1) above, Bidder must submit Copy of Detailed Letter of Acceptance (DLOA) / Work Order /relevant extract of work Order/ Contract Agreement alongwith Detailed scope of work, Completion / Acceptance Certificate and a certificate in respect of minimum one year successful operation of the Plant issued by the Owner/End user. The Detailed Letter of Acceptance (DLOA) / Work Order / Contract Agreement must clearly indicate nature of Work, period, and contract value. Similarly, the Completion Certificate/ Acceptance Certificate must clearly indicate reference of relevant work order/DLOA/Contract Agreement, Name of Work, Contract Value, Executed order value and date of completion.

(ii) Financial Criteria of BEC:

(a) To meet the criteria for Sr. No. 2.1, Bidder shall submit the Audited Financial Statements of the company for any one of the preceding three (03) financial years/Calendar years (i.e. FY 2018-19 / FY 2017-18 / FY 2016-17 or calendar years 2018/2017/2016) whichever meets the annual turnover criteria.

(b) To meet the criteria for Sr. No. 2.2, Bidder shall submit the last Audited Financial Statements (FY 2018-19 or calendar year 2018) alongwith “Details of Financial Capability of the Bidder” in prescribed format duly signed and stamped by Chartered Accountant.
(c) To meet the criteria for Sr. No. 2.3, Bidder shall submit the last Audited Financial Statements (FY 2018-19 or calendar year 2018) along with (i) Bank’s Letter (if applicable) and (ii) “Details of Financial Capability of the Bidder” in prescribed format duly signed and stamped by Chartered Accountant along with Bank’s letter for 2.3 (if applicable).

(d) If the bidder’s working capital is negative or inadequate, the bidder shall submit a letter from their bank having net worth not less than Rs.100 Crores (or equivalent USD), confirming the availability of line of credit for working capital amount mentioned herein above. The line of credit letter from bank to be submitted strictly as per format.

5.0 AUTHENTICATION OF DOCUMENTS SUBMITTED AGAINST BEC

5.1 All documents in support of Technical Criteria of Bid Evaluation Criteria (BEC) furnished by the bidders shall be verified and certified by any one of the following independent third party inspection agency (as per prescribed format at Appendix-I):

1. Société Générale de Surveillance (SGS)
2. Gulf Lloyds Industrial Services (India) Pvt. Ltd (GLISPL)
3. International Certification Services (ICS)
4. Bureau Veritas (Ind.) Pvt. Ltd (BVIS)
5. DNV GL
6. TUV Rheinland (India) Pvt. Ltd.
7. TÜV SÜD South Asia Pvt. Ltd.
8. TUV India Pvt. Ltd. (TÜV Nord Group)
9. Intertek India Pvt. Ltd.
10. Moody International (India) Pvt. Ltd.
11. RINA India Pvt. Ltd.
12. Tata Projects Ltd.
13. Competent Inspectorate and Consultants LLP
14. ABS Industrial Verification (India) Pvt. Ltd

All charges of the Third party for verification and certification shall be borne by the Bidder. TPIA will provide in addition a certificate towards verification and certification of documents pertaining to Technical PQC as per the prescribed format at Appendix-I given below.

If any above mentioned agency themselves are participating in bidding, then they shall authenticate the document by a different agency from the list given above.

5.2 For authentication of document submitted in support of Financial Criteria of Bid Evaluation criteria (BEC), copy of audited annual financial statements submitted with bid shall be duly certified / attested by Notary Public with legible stamp. Further, bidder shall submit “Details of financial capability of Bidder” in prescribed format duly signed and stamped by a Chartered Accountant/ Certified Public Accountant (CPA).

Note: In case, bidder submits ‘Details of financial capability of bidder’ in prescribed format in support of financial criteria of PQC duly signed and stamped by its **Statutory Auditor**, authentication of audited financial statements as mentioned above may not be necessary.
Appendix-I

Format for Undertaking from TPIA
(on TPIA letter head duly stamped & signed)

Ref.: Date:

To,

Talcher Fertilizers Limited.

Dear Sir,

Subject: Verification and certification of documents pertaining to Technical Bid Evaluation Criteria (BEC)

Ref: Tender no. ...................... for ............................

M/s. .................................. having Registered office at ............................................ intend to participate in above referred tender of Talcher Fertilizers Limited having its registered office at Plot 2/H, Kalpana Area, BJB Nagar, Khordha, Bhubaneswar-751014.

The tender conditions stipulates that the BIDDER shall submit Documents pertaining to Technical Bid Evaluation Criteria (BEC) duly verified and certified by designated independent Third Party Inspection Agency.

In this regard, this is to certify that copies of documents pertaining to Technical Bid Evaluation Criteria (BEC) submitted to us by the bidder have been verified and certified by us with the originals and found to be genuine. We have signed and stamped on the copies of all the verified and certified documents.

(Signature of a person duly authorized to Sign on behalf of the TPIA)
(Seal of the Company)
Name: ............................
Contact No......................
B. EVALUATION METHODOLOGY

The subject work is indivisible and complete work shall be awarded to successful overall lowest bidder as per evaluation methodology described below. In other words, evaluation of bids shall be done on overall L-1 basis considering all applicable taxes & duties including GST as under:

The Evaluation methodology shall be based on NPV arrived as per the following:

(a) **NPV OF TOTAL LUMPSUM TURNKEY (LSTK) PRICE/ TOTAL CONTRACT PRICE**

The TOTAL LSTK PRICE / TOTAL CONTRACT PRICE (Including all taxes, duties, levies and GST) as derived from the SCHEDULE OF PRICES will be discounted at the rate of 10.0% p.a., as per the cumulative monthly payment schedule / “S” curve submitted by the Bidder for the implementation period.

The Bidder shall furnish, the cumulative monthly payment schedule of its CONTRACT PRICE for 26 months project schedule in a tabular form as per prescribed format. The month-wise phasing of expenditure indicated by Bidder will be used for evaluation and form part of the CONTRACT for capping the monthly payment based on the actual progress of work. The cumulative monthly payment schedule / “S” curve has to be given by the bidders considering payment schedule given elsewhere in the tender.

(b) **NPV OF WORKS COST**

Bidder shall furnish the Guaranteed Consumption Figures of Raw Materials, Utilities and Condensate as per prescribed format (Annexure A of BOQ/Schedule of Price). The differential Works cost (in comparison to Bidder quoting the lowest Works Cost) considering 330 stream days per year will be calculated and will be discounted at discount rate of 10.0% p.a. for a period of 25 years of operation starting from Preliminary Acceptance.

The NPV of differential works cost so obtained on achieving Commissioning (26 months) shall be further discounted at the rate of 10.0% p.a to arrive at present value i.e. month zero

For Bid evaluation purpose, work cost shall be calculated for Guarantee Test run clause.

To summarize the above, the evaluated cost shall be ascertained as per following:

(a) NPV of quoted TOTAL CONTRACT PRICE

Plus (+)

(b) NPV of Works cost

(c) Optional prices quoted in the Schedule of Prices/BOQ shall not be considered in the evaluation
SECTION-III

INSTRUCTION TO BIDDERS

[TO BE READ IN CONJUNCTION WITH BIDDING DATA SHEET (BDS)]
SECTION-III
INSTRUCTION TO BIDDERS

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[A] – GENERAL

1 SCOPE OF BID
1.1 The Employer as defined in the "General Conditions of Contract [GCC]", wishes to receive Bids as described in the Tender document issued by Employer. Employer/Owner/TFL occurring herein under shall be considered synonymous.

1.2 SCOPE OF BID: The scope of work/ Services shall be as defined in the Tender documents.

1.3 The successful bidder will be expected to complete the scope of Bid within the period stated in Special Conditions of Contract.

1.4 Throughout the Tender documents, the terms 'Bid', 'Tender' & 'Offer' and their derivatives [Bidder/Tenderer, Bid/Tender/Offer etc.] are synonymous. Further, 'Day' means 'Calendar Day' and 'Singular' also means 'Plural'.

1.5 BRIEF SCOPE OF WORK:

There shall be three (03) Coal fired Boilers (2W+1S) either Circulating Fluidized Bed Combustion (CFBC) or Pulverized Coal (PC) type of identical capacity with total installed capacity (to be decided by bidder considering internal consumption within their B.L) based on net HP steam export figure of 564 TPH HP steam plus superheating of 74 TPH saturated HP steam. To meet the above requirement the bidder shall supply Basic Design and Detailed Engineering, HAZOP Study, Procurement, Supply, Fabrication, Third Party Inspection (TPI) as applicable, Expediting, Site Survey and Condition Assessment, Route Survey for ODCS, Insurance, Transportation of all Equipment / Materials to Work Site, Storage & Materials Management, Construction and Erection of all Civil, Mechanical, Electrical and Instrumentation Works, Assembly and Installation of Equipments, Packages, Obtaining all necessary Statutory Approvals, Testing, Mechanical Completion, Pre-Commissioning, Commissioning, Performance Guarantee Test Run including Complete Project Management and Handing Over of 'Steam Generation Plant' Comprising of Boilers with Steam Superheating Facility and all other associated Plant Auxiliaries like De-aeration System, Coal Processing, Transfer & Handling System, Ash Handling System etc. on a Lump-Sum Turnkey Basis under Single Point Responsibility Basis, at Talcher, Angul district, Odisha for Talcher Fertilizers Limited.

2 ELIGIBLE BIDDERS

2.1 The Bidder shall not be under a declaration of ineligibility by Employer for Corrupt/ Fraudulent/ Collusive/ Coercive practices, as defined in "Instructions to Bidders [ITB], Clause No. 39" (Action in case Corrupt/ Fraudulent/ Collusive/ Coercive Practices).

2.2 The Bidder is not put on ‘Holiday' by TFL or any of the JV partner of OWNER (viz. GAIL, RCF, CIL, FCIL) or Public-Sector Project Management Consultant (like PDIL only due to “poor performance” or “corrupt and fraudulent practices”) or banned/blacklisted by Government department/ Public Sector on due date of submission of bid or during the process of evaluation of bids. Further, neither bidder nor their allied agency/(ies) (as defined in the Procedure for Action in case of Corrupt/Fraudulent/Collusive/ Coercive Practices) are on banning list of TFL or any of the JV partner of OWNER viz. GAIL, RCF, CIL, FCIL.
If the Tender documents were issued inadvertently/ downloaded from website, offers submitted by such bidders shall not be considered for opening/ evaluation/Award and will be returned immediately to such bidders.

In case there is any change in status of the declaration prior to award of contract, the same has to be promptly informed to TFL/PDIL by the bidder.

It shall be the sole responsibility of the bidder to inform about their status regarding para 1 of clause 2.2 herein above on due date of submission of bid and during the course of finalization of the tender. Concealment of the facts shall tantamount to misrepresentation of facts and shall lead to action against such Bidders as per clause 39 of ITB.

2.3 The Bidder should not be under any liquidation court receivership or similar proceedings on due date of submission of bid. In case there is any change in status of the declaration prior to award of contract, the same has to be promptly informed to TFL/PDIL by the bidder.

It shall be the sole responsibility of the bidder to inform TFL there status on above on due date of submission of bid and during the course of finalization of the tender. Concealment of the facts shall tantamount to misrepresentation of facts and shall lead to action against such Bidders as per clause no. 39 of ITB.

2.4 Bidder shall not be affiliated with a firm or entity:

(i) that has provided consulting services related to the work to the Employer during the preparatory stages of the work or of the project of which the works/services forms a part of or
(ii) that has been hired (proposed to be hired) by the Employer as an Engineer/ Consultant for the contract.

2.5 Deleted.

2.6 Pursuant to qualification criteria set forth in the Tender document, the Bidder shall furnish all necessary supporting documentary evidence to establish Bidder’s claim of meeting qualification criteria.

2.7 **Power of Attorney:**

Power of Attorney to be issued by the bidder in favour of the authorised employee(s),in respect of the particular tender, for purpose of signing the documents including bid, all subsequent communications, agreements, documents etc. pertaining to the tender and act and take any and all decision on behalf of the bidder (including Consortium). Any consequence resulting due to such signing shall be binding on the Bidder (including Consortium).

(I) In case of a single Bidder, the power of Attorney shall be issued as per the constitution of the bidder as below:

a) **In case of Proprietorship:** By Proprietor
b) **In case of Partnership:** by all Partners or Managing Partner.
c) **In case of Limited Liability Partnership:** by any bidder’s employee authorized in terms of Deed of LLP.
d) **In case of Public /Limited Company:** POA in favour of authorized employee(s) by Board of Directors through Board Resolution or by the
designated officer authorized by Board to do so. Such Board Resolution should be duly countersigned by Company Secretary / MD / CMD / CEO.

The Power of Attorney should be valid till award of contract/order to successful bidder.

3 BIDS FROM "JOINT VENTURE"/"CONSORTIUM"
NOT APPLICABLE.

4 ONE BID PER BIDDER

4.1 A Bidder shall submit only 'one [01] Bid' in the same Bidding Process either as single entity or as a member of any consortium (wherever consortium bid is allowed). A Bidder who submits or participates in more than 'one [01] Bid' will cause all the proposals in which the Bidder has participated to be disqualified.

4.2 More than one bid means bid(s) by bidder(s) having same Proprietor / Partners / Limited Liability Partner in any other Bidder (s). Further, more than one bids shall also include two or more bidders having common power of attorney holder.

Failure to comply this clause during tendering process will disqualify all such bidders from process of evaluation of bids.

4.3 Alternative Bids shall not be considered.

4.4 The provisions mentioned at sl. no. (i) and (ii) shall not be applicable wherein bidders are quoting for different Items / Sections / Parts / Groups/ SOR items of the same tender which specifies evaluation on Items / Sections / Parts / Groups/ SOR items basis.

5 COST OF BIDDING
The Bidder shall bear all costs associated with the preparation and submission of the Bid including but not limited to Bank charges all courier charges including taxes & duties etc. incurred thereof. Further, TFL/PDIL will in no case, be responsible or liable for these costs, regardless of the outcome of the bidding process.

6 SITE VISIT
6.1 The Bidder is advised to visit and examine the site of works and its surroundings and obtain for itself on its own responsibility all information that may be necessary for preparing the Bid and entering into a Contract for the required job. The costs of visiting the site shall be borne by the Bidder.

6.2 The Bidder or any of its personnel or agents shall be granted permission by the Employer to enter upon its premises and land for the purpose of such visits, but only upon the express conditions that the Bidder, its personnel and agents will release and indemnify the Employer and its personnel, agents from and against all liabilities in respect thereof, and will be responsible for death or injury, loss or damage to property, and any other loss, damage, costs, and expenses incurred as a result of inspection.

6.3 The Bidder shall not be entitled to hold any claim against TALCHER FERTILIZERS LIMITED for non-compliance due to lack of any kind of pre-requisite information as it is the sole responsibility of the Bidder to obtain all the necessary information with regard to site, surrounding, working conditions, weather etc. on its own before submission of the bid.
7 CONTENTS OF TENDER DOCUMENTS

7.1 The contents of Tender documents / Tender Documents are those stated below, and should be read in conjunction with any 'Addendum / Corrigendum' issued in accordance with "ITB: Clause-9":

- Section-I : Invitation for Bid [IFB]
- Section-II : Bid Evaluation Criteria [BEC] & Evaluation Methodology
- Section-III : Instructions to Bidders [ITB], Annexures, Forms & Format
- Section-IV : General Conditions of Contract [GCC]
- Section-V : Special Conditions of Contract [SCC]
- Section-VI : Scope of Work & Specifications
- Section-VII : Price Schedule/ Schedule of Rates

*"Request for Quotation", wherever applicable, shall also form part of the Tender document.

7.2 The Bidder is expected to examine all instructions, forms, terms & conditions in the Tender documents. The "Request for Quotation [RFQ] & Invitation for Bid (IFB)" together with all its attachments thereto, shall be considered to be read, understood and accepted by the Bidders. Failure to furnish all information required by the Tender documents or submission of a Bid not substantially responsive to the Tender documents in every respect will be at Bidder's risk and may result in the rejection of his Bid.

8 CLARIFICATION OF TENDER DOCUMENTS

8.1 A prospective Bidder requiring any clarification(s) of the Tender documents may notify TFL in writing or through CPP Portal (https://etenders.gov.in/eprocure/app) or email at PDIL's mailing address indicated in the BDS no later than 02 (two) days prior to pre-bid meeting (in cases where pre-bid meeting is scheduled) or 05 (five) days prior to the due date of submission of bid in cases where pre-bid meeting is not scheduled. TFL/PDIL reserves the right to ignore the bidders request for clarification if received after the aforesaid period. TFL/PDIL may respond in writing to the request for clarification. TFL/PDIL's response including an explanation of the query, but without identifying the source of the query will be uploaded on the websites at Clause No. 2.0 (G) of IFB and communicated to prospective bidders by e-mail.

8.2 Any clarification or information required by the Bidder but same not received by the Employer at clause 8.1 (refer BDS for address) above is liable to be considered as "no clarification / information required".

9 AMENDMENT OF TENDER DOCUMENTS

9.1 At any time prior to the 'Bid Due Date', Owner may, for any reason, whether at its own initiative or in response to a clarification requested by a prospective Bidder, modify the Tender documents by amendment / corrigendum.

9.2 Any corrigendum thus issued shall be integral part of the Tender Document and shall be hosted on the websites as provided at clause no. 2.0 (G) of IFB /communicated to prospective bidders by e-mail. Bidders have to take into account all such amendment / corrigendum before submitting their Bid.
9.3 The Employer, if it considers necessary, may extend the date of submissions of Bid in order to allow the Bidders a reasonable time to furnish their most competitive bid taking into account the amendment / corrigendum issued thereof.

[C] – PREPARATION OF BIDS

10 **LANGUAGE OF BID:**
The bid prepared by the Bidder and all correspondence, document(s), certificate(s) etc. relating to the Bid exchanged by Bidder and TFL shall be written in English language only. In case a document, certificate, printed literature etc. furnished by the Bidder in a language other than English, the same should be accompanied by an English translation duly authenticated by the Chamber of Commerce of Bidders Country, in which case, for the purpose of interpretation of the Bid, the English translation shall govern.

11. **DOCUMENTS COMPRISING THE BID**
11.1 Bidders are requested to refer instructions for participating in E-Tendering and the ready reckoner for bidders available at [https://etenders.gov.in/eprocure/app](https://etenders.gov.in/eprocure/app). Bids submitted manually shall be rejected.

The bids must be submitted on E-tendering website of CPP portal ([https://etenders.gov.in/eprocure/app](https://etenders.gov.in/eprocure/app)) comprising following documents:-

11.1.1 **PART-I: "TECHNO-COMMERCIAL / UN-PRICED BID”** shall contain the following:

(a) 'Covering Letter' on Bidder's 'Letterhead' clearly specifying the enclosed contents.
(b) Duly attested documents in accordance with the "BID EVALUATION CRITERIA [BEC]" establishing the qualification.
(c) 'Bidder's General Information', as per 'Form F-1'.
(d) Copies of documents, as specified in tender document.
(e) As a confirmation that the prices are quoted in requisite format complying with the requirements copy of Schedule of Rate (SOR) with prices blanked out mentioning quoted / not quoted (as applicable) written against each item.
(f) 'Letter of Authority' on the Letter Head, as per 'Form F-3'.
(g) 'Agreed Terms and Conditions', as per 'Form F-5'.
(h) 'Acknowledgement cum Consent Letter', as per 'Form F-6'.
(i) Copy of Power of Attorney as per 'F-10' /copy of Board Resolution, in favour of the authorized signatory of the Bid, as per clause no.2.7 of ITB (Original to be submitted physically).
(j) Copy of EMD in original as per Clause 16 of ITB (Original to be submitted physically).
(k) All forms and Formats including Annexures.
(l) ‘Integrity Pact’ as per ‘Form F-14’
(m) ‘Indemnity Bond’ as per ‘Form F-15’
(n) Tender Document duly signed/ digitally signed by the Authorized Signatory.
(o) Additional document specified in Bidding Data Sheet (BDS).
(p) Any other information/details required as per Tender Document.

Note:

1. All the pages of the Bid must be signed/ digitally signed by the "Authorized Signatory" of the Bidder.

2. Forms F-4 and F-14 are not to be filled up at this stage as these will be executed only with successful bidder. However, bidders to be participated in this tender.
shall produce an acknowledgement regarding acceptance of prescribed format without any deviations at Sr. No. 22 of ‘Agreed Terms & Conditions as per F-5’ & same shall be produced in case they emerge as successful bidder.

11.1.2 PART-II: Price Bid
i) The Prices are to be submitted strictly as per the Schedule of Rate of the Tender documents. TFL/PDIL shall not be responsible for any failure on the part of the bidder to follow the instructions.

ii) Bidders are advised NOT to mention Rebate/Discount separately, either in the SOR format or anywhere else in the offer. In case Bidder(s) intend to offer any Rebate/Discount, they should include the same in the item rate(s) itself under the “Schedule of Rates (SOR)” and indicate the discounted unit rate(s) only.

iii) If any unconditional rebate has been offered in the quoted rate the same shall be considered in arriving at evaluated price. However no cognizance shall be taken for any conditional discount for the purpose of evaluation of the bids.

iv) In case, it is observed that any of the bidder(s) has/have offered suo-moto Discount/Rebate after opening of unpriced bid but before opening of price bids such discount /rebate(s) shall not be considered for evaluation. However, in the event of the bidder emerging as the lowest evaluated bidder without considering the discount/rebate(s), then such discount/rebate(s) offered by the bidder shall be considered for Award of Work and the same will be conclusive and binding on the bidder.

v) In the event as a result of techno-commercial discussions or pursuant to seeking clarifications / confirmations from bidders, while evaluating the un-priced part of the bid, any of the bidders submits a sealed envelope stating that it contains revised prices; such bidder(s) will be requested to withdraw the revised prices failing which the bid will not be considered for further evaluation.

vi) In case any bidder does not quote for any item(s) of “Schedule of Rates” and the estimated price impact is more than 10% of the quoted price, then the bid will be rejected. If such price impact of unquoted items is 10% or less of his quoted price, then the unquoted item(s) shall be loaded highest of the price quoted by the other bidders. If such bidder happens to be lowest evaluated bidder, price of unquoted items shall be considered as included in the quoted bid price.

11.2 Bidders must submit the original "EMD, Power of Attorney, Integrity Pact and TPI letter as specified in the Tender Document to the address mentioned in IFB, in a sealed envelope, superscribing the details of Tender Document (i.e. tender number & tender for) within 7 days from the date of un-priced bid opening.

Bidders are required to submit the EMD in original by Due Date and Time of Bid Submission or upload a scanned copy of the same in the Part-I of the Bid. If the Bidder is unable to submit EMD in original by Due Date and Time of Bid Submission, the Bidder is required to upload a scanned copy of the EMD in Part-I of Bid, provided the original EMD, copy of which has been uploaded, is received within 7 days from the Due Date of Bid Opening, failing which the Bid will be rejected irrespective of their status/ranking in tendering process and notwithstanding the fact that a copy of EMD was earlier uploaded by the Bidder.

11.3 The Prices are to be filled strictly in the Schedule of Rate of the bidding documents and provision mentioned at para 11.1.2 hereinabove and to be uploaded in CPP portal.
12 **SCHEDULE OF RATES / BID PRICES**

12.1 Unless stated otherwise in the Tender documents, the Contract shall be for the whole works as described in Tender documents, based on the rates and prices submitted by the Bidder and accepted by the Employer.

12.2 Prices must be filled in format for "Schedule of Rates [SOR]"/"BOQ" enclosed as part of Tender document. If there is any variation in item description, unit or quantity vis-à-vis SOR format of Tender Document; the Bid is liable to be rejected.

12.3 Bidder shall quote for all the items of "SOR" after careful analysis of cost involved for the performance of the completed item considering all parts of the Tender document. In case any activity though specifically not covered in description of item under "SOR" but is required to complete the works as per Specifications, Scope of Work / Service, Standards, General Conditions of Contract ("GCC"), Special Conditions of Contract ("SCC") or any other part of Tender document, the prices quoted shall deemed to be inclusive of cost incurred for such activity.

12.4 All duties, taxes and other levies [if any] payable by the Contractor under the Contract, or for any other cause except final GST (CGST & SGST/ UTGST or IGST) shall be included in the rates / prices and the total bid-price submitted by the Bidder. Applicable rate of GST (CGST & SGST/ UTGST or IGST) on the contract value shall be indicated in Agreed Terms & Conditions (Format-F5) and SOR.

12.5 Prices quoted by the Bidder, shall remain firm and fixed and valid until completion of the Contract and will not be subject to variation on any account. Any new taxes & Duties, if imposed by the State/ Govt. of India after due date of bid submission but before the expiry of contract period, shall be reimbursed to the contractor on submission of documentary evidence for proof of payment to State/ Govt. Authorities and after ascertaining it's applicability with respect to the contract.

12.6 Further, Bidder shall also mention the Service Accounting Codes (SAC) / Harmonized System of Nomenclature (HSN) at the designated place in SOR.

13 **GST (CGST & SGST/ UTGST or IGST)**

13.1 Bidders are required to mention the GST Registration number in bids wherever GST (CGST & SGST/UTGST or IGST) is applicable.

13.2 Please note that the responsibility of payment of GST (CGST & SGST or IGST or UTGST) lies with the Service Provider only. Service Provider providing taxable service shall issue tax Invoice/ Bill, as the case may be as per rules/ regulation of GST. Further, returns and details required to be filled under GST laws & rules should be timely filed by Service Provider with requisite details.

Payments to Service Provider for claiming GST (CGST & SGST/UTGST or IGST) amount will be made provided the above formalities are fulfilled. Further, TFL may seek copies of challan and certificate from Chartered Accountant for deposit of GST (CGST & SGST/UTGST or IGST) collected from Owner.

13.3 In case CBIC (Central Board of Indirect Taxes and Customs)/ any equivalent Central Government agency/ State Government agency brings to the notice of TFL that the Supplier of Goods / Services (Service Provider) has not remitted the amount towards GST (CGST & SGST/UTGST or IGST) collected from TFL to the government exchequer, then, that Contractor shall be put under Holiday list of TFL.
for a period of six months after following the due procedure. This action will be in addition to the right of recovery of financial implication arising on TFL.

13.4 For statutory variation in GST (CGST & SGST/UTGST or IGST), please refer clause no. 13.0 of SCC (Section V of NIT)

13.5 TFL will reimburse GST (CGST & SGST/UTGST or IGST) to the Contractor at actuals against submission of Tax Invoices as per format specified in rules/ regulation of GST, subject to any statutory variations.

The bids will be evaluated based on total price including applicable GST (CGST & SGST/UTGST or IGST).

13.6 TFL will prefer to deal with registered contractors under GST. Therefore, bidders are requested to get themselves registered under GST, if not registered yet.

However, in case any unregistered bidder is submitting their bid, their prices will be loaded with applicable GST (CGST & SGST/UTGST or IGST) while evaluation of bid.

13.7 In case TFL is required to pay entire/certain portion of applicable GST (CGST & SGST/UTGST or IGST) and remaining portion, if any, is to be deposited by Bidder directly as per GST (CGST & SGST/UTGST or IGST) laws, entire applicable rate/amount of GST (CGST & SGST/UTGST or IGST) to be indicated by bidder in the SOR.

Where TFL has the obligation to discharge GST (CGST & SGST/UTGST or IGST) liability under reverse charge mechanism and TFL has paid or is liable to pay GST (CGST & SGST/UTGST or IGST) to the Government on which interest or penalties becomes payable as per GST laws for any reason which is not attributable to TFL or ITC with respect to such payments is not available to TFL for any reason which is not attributable to TFL, then TFL shall be entitled to deduct/ setoff / recover such amounts against any amounts paid or payable by TFL to Contractor.

13.8 Contractor shall ensure timely submission of correct Tax invoice(s) as per rules/ regulations of GST with all required supporting document(s) within a period specified in Contracts/ DLOA to enable TFL to avail input tax credit. Further, returns and details required to be filled under GST laws & rules should be timely filed by Contractor with requisite details.

13.9 Anti-profiteering clause
As per Clause 171 of GST Act it is mandatory to pass on the benefit due to reduction in rate of tax or from input tax credit to the consumer by way of commensurate reduction in prices. The Contractor may note the above and quote their prices accordingly.

13.10 In case the GST rating of vendor on the GST portal / Govt. official website is negative / black listed, then the bids may be rejected by TFL. Further, in case rating of bidder is negative / black listed after award of work, then TFL shall not be obligated or liable to pay or reimburse GST to such vendor and shall also be entitled to deduct / recover such GST along with all penalties / interest, if any, incurred by TFL.

13.11 The Contractor shall mention the particulars of Talcher Fertilizers Limited, (place specified in BDS) on the Invoice. Besides, if any other particulars of Talcher Fertilizers Limited are required to be mentioned, under GST rules/ regulations, the same shall also be mentioned on the Invoice.
13.12 The rate of GST as quoted in Price Schedule/SOR shall be considered as the prevailing present applicable rates on the Bid due date and same shall be considered for price comparison as well as for ordering. Any error of judgment on part of the Bidder in identifying the present applicable rates shall not be admitted. The applicable rate of GST as indicated by the bidders in Price Schedule/SOR shall be considered as the maximum payable in the event when no statutory variations take place and any remainder/balance GST, if payable, beyond that quoted rates shall be borne by the Bidder. However, in the event of any statutory variations in the rate of GST, if the quoted rates are found erroneous then the base rates for calculation of statutory variations for the purpose of reimbursement of GST shall take into account either the rates actually prevalent on the due date of submission of bid or the erroneous rates quoted by the Bidders whichever is beneficial to TFL. Consequently, any difference in GST if it becomes payable to the tax authorities shall be borne by the Bidder.

13.13 The CONTRACTOR confirms that it has included all taxes, duties, levies etc., as applicable at prevailing rates, in its SCHEDULE OF RATES. In case, CONTRACTOR has not included any such taxes, duties, levies etc., at all and/or at prevailing rates and CONTRACTOR has to pay such taxes, duties, levies etc., OWNER shall not be liable for payment of such liabilities and/or OWNER shall not reimburse such taxes, duties, levies etc. to CONTRACTOR.

13.14 Wherever TDS under GST Laws has been deducted from the Tax invoices raised / payments made to the vendors, as per the provisions of the GST law / Rules, Vendors should accept the corresponding GST-TDS amount populated in the relevant screen on GST common portal (www.gst.gov.in). Further, Vendors should also download the GST TDS certificate from GST common portal (reference path: Services>User Services> View/Download Certificates option).

13.15 **Deduction of TDS on GST**

As per notification no. 50/2018-Central Tax dated 13.09.2018, deduction of tax under GST became effective w.e.f. 01.10.2018 and accordingly applicable TDS under GST shall be deducted from Contractor’s Invoice.

14 **BID CURRENCIES:**

Bidders must submit bid in Indian Rupees only.

15 **BID VALIDITY**

15.1 Bids shall be kept valid for period specified in BDS from the final due date of submission of bid’. A Bid valid for a shorter period may be rejected by TFL as 'non-responsive'.

15.2 In exceptional circumstances, prior to expiry of the original 'Bid Validity Period', the Employer may request the Bidders to extend the 'Period of Bid Validity' for a specified additional period. The request and the responses thereto shall be made in writing or by email. A Bidder may refuse the request without forfeiture of his EMD. A Bidder agreeing to the request will not be required or permitted to modify his Bid but will be required to extend the validity of its EMD for the period of the extension and in accordance with "ITB: Clause-16" in all respects.
16 **EARNEST MONEY DEPOSIT**

16.1 Bid must be accompanied with earnest money (i.e Earnest Money Deposit (EMD) also known as *Bid Security*) in the form of ‘Demand Draft’ / ‘Banker’s Cheque’[in favour of *Talcher Fertilizers Limited* payable at place mentioned in BDS] or ‘Bank Guarantee’ strictly as per the format given in form F-2 (as the case may be) of the Tender Document. Bidder shall ensure that EMD submitted in the form of ‘Bank Guarantee’ should have a validity of at least two [02] months beyond the validity of the Bid. EMD submitted in the form of ‘Demand Draft’ or ‘Banker’s Cheque’ should be valid for three months.

Bid not accompanied with EMD, or EMD not in requisite format shall be liable for rejection. The EMD shall be submitted in Indian Rupees only.

16.2 EMD shall not be accepted in case the same has reference of ‘remitter’ / ‘financer’ other than bidder on the aforementioned financial instrument of EMD submitted by the bidder and bid of such bidder will be summarily rejected.

16.3 OWNER shall not be liable to pay any documentation charges, Bank charges, commission, interest etc. on the amount of EMD. In case EMD is in the form of a ‘Bank Guarantee’, the same shall be from any Indian scheduled Bank or a branch of an International Bank situated in India and registered with ‘Reserve Bank of India’ as Scheduled Foreign Bank. However, in case of ‘Bank Guarantee’ from Banks other than the Nationalized Indian Banks, the Bank must be commercial Bank having net worth in excess of Rs. 100 Crores [Rupees One Hundred Crores] and a declaration to this effect should be made by such commercial Bank either in the ‘Bank Guarantee’ itself or separately on its letterhead.

16.4 Any Bid not secured in accordance with “ITB: Clause-16.1 & Clause-16.3” may be rejected by TFL as non-responsive.

16.5 Unsuccessful Bidder’s EMD will be discharged/ returned as promptly as possible, but not later than ‘thirty [30] days’ after finalization of tendering process.

16.6 The successful Bidder’s EMD will be discharged upon the Bidder’s acknowledging the ‘Award’ and signing the ‘Agreement’ (if applicable) and furnishing the ‘Contract Performance Security (CPS)/ Security Deposit’ pursuant to clause no. 38 of ITB.

16.7 Notwithstanding anything contained herein, the EMD may also be forfeited in any of the following cases:
   (a) If a Bidder withdraws his Bid during the ‘Period of Bid Validity’
   (b) If a Bidder has indulged in corrupt/fraudulent /collusive/coercive practice
   (c) If the Bidder modifies Bid during the period of bid validity (after Due Date and Time for Bid Submission).
   (d) Violates any other condition, mentioned elsewhere in the Tender Document, which may lead to forfeiture of EMD.
   (e) In case of Cartelization of bid
   (f) In the case of a successful Bidder, if the Bidder fails to:
      (i) to acknowledge receipt of the “Notification of Award” / Fax of Acceptance[FOA] / Detailed Letter of Acceptance [DLOA]”,
      (ii) to furnish “Contract Performance Security / Security Deposit”, in accordance with “ITB: Clause-38”

16.8 In case EMD is in the form of ‘Bank Guarantee’, the same must indicate the Tender Document No. and the name of Tender Document for which the Bidder is quoting. This is essential to have proper correlation at a later date.
16.9 MSEs (Micro & Small Enterprises) are exempted from submission of EMD in accordance with the provisions of PPP-2012 and Clause 40 of ITB. However, Traders/Dealers/ Distributors /Stockiest /Wholesaler are not entitled for exemption of EMD. The Government Departments/PSUs are also exempted from the payment of EMD. Further, Startups are also exempted from the payment of EMD.

16.10 In case of forfeiture of EMD/ Bid Security, the forfeited amount will be considered inclusive of tax and tax invoice will be issued by TFL. The forfeiture amount will be subject to final decision of TFL based on other terms and conditions of order/contract.

17 **PRE-BID MEETING**

17.1 The Bidder(s) or his designated representative are invited to attend a "Pre-Bid Meeting" which will be held at address specified in IFB. It is expected that a bidder shall not depute more than 02 representatives for the meeting.

17.2 Purpose of the meeting will be to clarify issues and to answer questions on any matter that may be raised at that stage and give hands-on e-tendering.

17.3 Text of the questions raised and the responses given, together with any responses prepared after the meeting, will be uploaded on websites as mentioned at Clause No. 2.0 (G) of IFB. Any modification of the Contents of Tender documents listed in "ITB: Clause-7.1", that may become necessary as a result of the Pre-Bid Meeting shall be made by the Employer exclusively through the issue of a Corrigendum pursuant to "ITB: Clause-9", and not through the minutes of the Pre-Bid Meeting.

17.4 Non-attendance of the Pre-Bid Meeting will not be a cause for disqualification of Bidder.

18 **FORMAT AND SIGNING OF BID**

18.1 The original and all copies of the Bid shall be typed or written in indelible ink [in the case of copies, photocopies are also acceptable] and shall be signed by a person or persons duly authorized to sign on behalf of the Bidder (as per POA). The name and position held by each person signing, must be typed or printed below the signature.

18.2 The Bid shall contain no alterations, omissions, or additions, unless such corrections are initialed by the person or persons signing the Bid.

18.3 Digitally signed documents to be uploaded as detailed in addendum to ITB.

19 **ZERO DEVIATION AND REJECTION CRITERIA**

19.1 ZERO DEVIATION: Deviation to terms and conditions of "Tender documents" may lead to rejection of bid. TFL will accept bids based on terms & conditions of "Tender documents" only. Bidder may note TFL will determine the substantial responsiveness of each bid to the Tender documents pursuant to provision contained in clause 29 of ITB. For purpose of this, a substantially responsive bid is one which conforms to all terms and conditions of the Tender documents without deviations or reservations. TFL’s determination of a bid’s responsiveness is based on the content of the bid itself without recourse to extrinsic evidence. TFL reserves the right to raise technical and/or commercial query(s), if required, may be raised on the bidder(s). The
response(s) to the same shall be in writing, and no change in the price(s) or substance of the bids shall be sought, offered or permitted. The substance of the bid includes but not limited to prices, completion, scope, technical specifications, etc. Bidders are requested to not to take any deviation/exception to the terms and conditions laid down in this "Tender Documents", and submit all requisite documents as mentioned in this "Tender Documents", failing which their offer will be liable for rejection. If a bidder does not reply to the queries in the permitted time frame, then its bid shall be evaluated based on the documents available in the bid.

19.2 **REJECTION CRITERIA:** Notwithstanding the above, deviation to the following clauses of Tender document shall lead to summarily rejection of Bid:

(a) Firm Price 
(b) Earnest Money Deposit / Bid Security 
(c) Specifications & Scope of Work 
(d) Schedule of Rates / Price Schedule / Price Basis 
(e) Duration / Period of Contract/ Completion Period 
(f) Payment Terms 
(g) Period of Validity of Bid 
(h) Integrity Pact 
(i) Mutually Agreed Damages 
(j) Overall ceiling on total liability 
(k) Contract Performance Security 
(l) Guarantee / Defect Liability Period 
(m) Patent Infringement and Indemnifications 
(n) Arbitration / Settlement of Dispute 
(o) Governing laws, language & measures 
(p) Force Majeure 
(q) Any other condition specifically mentioned in the tender document elsewhere that non-compliance of the clause lead to rejection of bid

Note: Further, it is once again reminded not to mention any condition in the Bid which is contradictory to the terms and conditions of Tender document.

20 **PAYMENT**

OWNER has initiated payments to Suppliers and Contractors through RTGS / NEFT. The successful bidder should give the details of his bank account as per the E-Banking Mandate Form (F-12).

[D] – **SUBMISSION OF BIDS**

21 **SUBMISSION, SEALING AND MARKING OF BIDS**

21.1 Bids shall be submitted through e-tender mode on CPP portal ([https://etenders.gov.in/eprocure/app](https://etenders.gov.in/eprocure/app)) in the manner specified elsewhere in tender document.

21.2 All the original/hard/physical copy of bids shall be addressed to the Consultant at address specified in IFB.

21.3 Bids submitted under the name of AGENT/ CONSULTANT/ REPRESENTATIVE/ RETAINER/ ASSOCIATE etc. on behalf of a bidder/affiliate shall not be accepted.
22 **DEADLINE FOR SUBMISSION OF BIDS**

22.1 Bids must be submitted through e-tender mode on CPP portal not later than the date and time specified in the BDS (Bidding Data Sheet).

22.2 **DELETED**

22.3 OWNER may, in exceptional circumstances and at its discretion, extend the deadline for submission of Bids (clause 9 of ITB refers). In which case all rights and obligations of OWNER and the Bidders, previously subject to the original deadline will thereafter be subject to the deadline as extended. Notice for extension of due date of submission of bid will be uploaded on website as mentioned in Clause No. 2.0(G) of IFB / communicated to the bidders.

23 **LATE BIDS**

E-tendering system shall close immediately after the due date for submission of bid and no bids can be submitted thereafter until unless the due date extended further. The bid bond/physical documents have been received but the bid is not submitted by the bidder on CPP portal (https://etenders.gov.in/eprocure/app), such bid bond/physical documents shall be returned immediately.

24 **MODIFICATION AND WITHDRAWAL OF BIDS**

The bidder may withdraw or modify its bid after bid submission but before the due date and time for submission as per tender document.

25 **EMPLOYER’S RIGHT TO ACCEPT ANY BID AND TO REJECT ANY OR ALL BIDS**

TFL reserves the right to accept or reject any Bid, and to annul the Bidding process and reject all Bids, at any time prior to award of Contract, without thereby incurring any liability to the affected Bidder or Bidders or any obligations to inform the affected Bidder or Bidders of the ground for TFL's action. However, Bidder if so desire may seek the reason (in writing) for rejection of their Bid to which TFL shall respond quickly.

[E] – **BID OPENING AND EVALUATION**

26 **BID OPENING**

26.1 **Unpriced Bid Opening:**

TFL will open bids, in the presence of bidders’ designated representatives who choose to attend, at date, time and location stipulated in the BDS. The bidders’ representatives, who are present, shall sign a bid opening register evidencing their attendance.

26.2 **Priced Bid Opening:**

26.2.1 TFL will open the price bids of those bidders who meet the qualification requirement and whose bids are determined to be technically and commercially responsive. Bidders selected for opening of their price bids shall be informed about the date of price bid opening. Bidders may depute their authorized representative to attend the bid opening. The bidders’ representatives, who are present shall sign a register
evidencing their attendance and may be required to be present on a short notice.

26.2.2 The price bids of those Bidders who were not found to be techno-commercially responsive shall not be opened. The Price bids for acceptable bidder shall be opened by OWNER/PMC.

26.2.3 The Price Evaluation of the Bids shall be carried by OWNER offline, as per Evaluation Methodology as specified under Section II of the tender document. Subsequently, Reverse Auction shall be carried out by OWNER/PMC on a separate Reverse Auction portal. The details of which shall be intimidated to the bidders.

26.3 Reverse Auction

26.3.1 OWNER shall finalize tender after conducting reverse auction except in those cases where less than four techno-commercially acceptable offers are available.

In case, after techno-commercial evaluation, number of technically & commercially acceptable offers are less than 04 (four), then no reverse auction will be conducted (but the OWNER/CONSULTANT shall take appropriate decision regarding conducting offline price negotiation, if required).

Accordingly, the decision to conduct reverse auction shall be communicated to shortlisted bidders prior to opening of price bid. The due date and time of conducting the event of Reverse Auction (if conducted) shall be intimated well in advance to the techno-commercially acceptable bidders, through email.

26.3.2 Types of Reverse Auction

(i) “Rank with L-1 Price” bid format:

In “Rank with L-1 Price” bid format, during the process of Reverse Auction, the short-listed bidders will be able to see only the current lowest price and their respective ranks/position during the online bidding process in the system, based on which they can reduce their prices. This type of auction shall be adopted in those tenders where Purchase preferences are not applicable.

At no point of time will any bidder see names of other bidders, or prices of bidders other than the lowest bid.

(ii) “Rank Only” bid format:

In “Rank Only” bid format, during the process of Reverse Auction, short-listed bidders will be able to see only their respective ranks/position during the online bidding process in the system, based on which they can reduce their prices. This type of auction is adopted in case of tenders, where purchase preference (for CPSU's/MSEs / PP-LC/DMEP/ PP for Telecom Goods, Works and Services etc.) is applicable, so as to take care of Purchase Preference at the end of the Reverse Auction.

The choice of the type of auction i.e. “Rank with L-1 price” or “Rank Only” shall be decided by the TFL at the time of short-listing of the bidders depending on the bidders at that stage who are eligible for Purchase Preference.
26.3.3 Reverse Auction shall be conducted with the evaluated price of various bidders as the bid opening price of the respective bidders.

26.3.4 The evaluated price (as per evaluation criteria defined in tender document) of the shortlisted bidders shall be automatically populated immediately on start of the Reverse Auction. Further, the start price of bidders will be automatically populated by system at the time of start of Reverse Auction. The same will be considered as participation by bidder in online Reverse Auction process.

26.3.5 During Reverse Auction, a bidder can reduce his prices repeatedly. The minimum percentage reduction in each step namely, ‘the bid decrement’ shall not be less than 0.5% of the last bid of the respective bidder. Bidders are allowed to submit/accept first price without decrement amount but afterwards participation in reverse auction is allowed only with minimum decrement amount/percentage.

26.3.6 During the Reverse Auction, bidders shall be allowed to decrease only the “TOTAL CONTRACT PRICE (excluding GST)” quoted by the bidder. The Monthly Payment Schedule and the work cost figures submitted by the bidder shall remain unchanged. However, the system shall automatically calculate the evaluated price as per the tender conditions and calculate the evaluated L-1 price. The acceptable bidders shall be informed about their respective loading factors before start of the Reverse Auction process.

26.3.8 In case any bidder emerges lowest bidder after RA based on their start price (s), the same will be considered as their final price (s) for award of contract/order irrespective of whether bidder had actually logged in RA portal or not. In case bidder does not accept the same, such bidder will be considered as errant bidder and action will be taken against bidder as per provision in this regard.

26.3.9 Bidders in their own interest should ensure uninterrupted internet connectivity at their end during the reverse auction with necessary backups to take care of any connectivity problem. However, in case of failure in connectivity of any of the bidders, the reverse auction time shall be extended against the request of bidders provided such request is received within the auction time. Such extensions shall each be of 10 minutes and no more than two requests per bidder for such extensions shall be entertained in the auction. The extension of auction time shall be communicated to all the bidders through system broadcast message and intimated telephonically to the bidders who are disconnected from reverse auction at that point of time.

If TFL/CONSULTANT is unable to extend the auction time due to some unavoidable reason and the auction happens to end before such extension, TFL/CONSULTANT reserves the right to launch a fresh auction immediately with the last bid price of the respective bidder during earlier auction as starting price.

26.3.10 All timings of the online bid shall be based on the time indicated by the Server hosting the Auction Engine which would reflect as closely as possible the Indian Standard Time (IST) i.e. GMT+0530 hrs. However, in the event of any deviations between the Server Time and the Indian Standard Time, the functioning of the Auction Engine (launch, operation and closure) would be guided by the Server time. Bidders should be advised to refresh the window of the Auction module and check the exact Server Time.
26.3.11 The process of Online Reverse Auction shall initially be held for a period of 30 minutes. In the event of a bid received in the last 5 minutes resulting in a change of prevailing L1 price, the period of the auction shall get extended automatically by 8 minutes (for “Rank with L-1 price” option) and 10 minutes (for “Rank Only” option) from the time of submission of such bid. This process will continue till no change in L-1 price takes place in last 5 minutes. Then the auction will close.

26.3.12 All bidders regardless of their previous position can submit their bid during the extended period also.

26.3.13 In case of a tie during auction i.e. two bidders entering same lowest price, the bidder who enters the prices first in the system would be taken as L-1 and the other bidder would see their ranking as L-2.

26.3.14 In case, no conclusion can be drawn from reverse auction from best bid history or where reverse auction is inconclusive on account of system malfunctioning or break in internet connectivity at TFL/CONSULTANT system end, reverse auction shall be re-conducted.

26.3.15 Detailed methodology of Reverse Auction shall be intimated to techno-commercially acceptable bidders before conduction of reverse auction.

With the assistance of RA system provider, training to all eligible bidders on the Online Reverse Auction process shall be facilitated prior to conduct of Online Reverse Auction.

26.3.16 Preferences: Purchase Preference shall be applicable as defined in tender document.

27 **CONFIDENTIALITY**

Information relating to the examination, clarification, evaluation and comparison of Bids, and recommendations for the award of a Contract, shall not be disclosed to Bidder(s) or any other persons not officially concerned with such process.

28 **CONTACTING THE EMPLOYER**

28.1 From the time of Bid opening to the time of award of Contract, if any Bidder wishes to contact the Employer on any matter related to the Bid, it should do so in writing. Information relating to the examination, clarification, evaluation & recommendation for award shall not be disclosed.

28.2 Any effort by the Bidder to influence the Employer in the Employer's 'Bid Evaluation', 'Bid Comparison', or 'Contract Award' decisions may result in the rejection of the Bidder's Bid and action shall be initiated as per procedure in this regard.

29 **EXAMINATION OF BIDS AND DETERMINATION OF RESPONSIVENESS**

29.1 The owner’s determination of a bid’s responsiveness is based on the content of the bid only. Prior to the detailed evaluation of Bids, the Employer will determine whether each Bid:

(a) Meets the "Bid Evaluation Criteria" of the Tender documents;
(b) Has been properly signed;
(c) Is accompanied by the required 'Earnest Money / Bid Security';
(d) Is substantially responsive to the requirements of the Tender documents; and
(e) Provides any clarification and/or substantiation that the Employer may require to determine responsiveness pursuant to "ITB: Clause-29.2"

29.2 A substantially responsive Bid is one which conforms to all the terms, conditions and specifications of the Tender documents without material deviations or reservations or omissions for this purpose employer defines the foregoing terms below:

a) “Deviation” is departure from the requirement specified in the tender documents.

b) “Reservation” is the setting of limiting conditions or withholding from complete acceptance of the requirement in the tender documents.

c) “Omission” is the failure to submit part or all of the information or documentation required in the tender document.

29.3 A material deviation, reservation or omission is one that,

a) If accepted would,

i) Affect in any substantial way the scope, quality, or performance of the job as specified in tender documents.

ii) Limit, in any substantial way, inconsistent with the Tender Document, the Employer’s rights or the tenderer’s obligations under the proposed Contract.

b) If rectified, would unfairly affect the competitive position of other bidders presenting substantially responsive bids.

29.4 The employer shall examine all aspects of the bid to confirm that all requirements have been met without any material deviation, reservation or omission.

29.5 If a Bid is not substantially responsive, it may be rejected by the Employer and may not subsequently be made responsive by correction or withdrawal of the of material deviation, reservation or omission.

30 DELETED.

31 CONVERSION TO SINGLE CURRENCY FOR COMPARISON OF BIDS

Not Applicable. All bids submitted must be in the currency specified at clause 14 of ITB.

32 EVALUATION AND COMPARISON OF BIDS

Bid shall be evaluated as per Evaluation Methodology mentioned under Section-II of Tender documents.

33 DELETED

34 PURCHASE PREFERENCE

Purchase preference to Central government public sector Undertaking, Local Content (PP-LC) bidders and Micro and Small Enterprises (MSEs) shall be allowed as per Government instructions in vogue.
**[F] – AWARD OF CONTRACT**

**35 **AWARD

Subject to "ITB: Clause-29", Owner will award the Contract to the successful Bidder whose Bid has been determined to be substantially responsive and has been determined as the lowest provided that bidder, is determined to be qualified to satisfactorily perform the Contract.

**36 **NOTIFICATION OF AWARD / FAX OF ACCEPTANCE

36.1 Prior to the expiry of 'Period of Bid Validity', Notification of Award for acceptance of the Bid will be intimated to the successful Bidder by OWNER either by E-mail /Letter or like means defined as the "Fax of Acceptance (FOA)". The Contract shall enter into force on the date of FOA and the same shall be binding on OWNER and successful Bidder (i.e. Contractor/Service Provider). The Notification of Award/FOA will constitute the formation of a Contract. The Detailed Letter of Acceptance shall be issued thereafter incorporating terms & conditions of Tender Document, Corrigendum, Clarification(s), Bid and agreed variation(s)/acceptable deviation(s), if any. OWNER may choose to issue Notification of Award in form of Detailed Letter of Acceptance without issuing FOA and in such case the Contract shall enter into force on the date of Detailed Letter of Acceptance only.

36.2 Contract period shall commence from the date of "Notification of Award" or as mentioned in the Notification of Award. The "Notification of Award" will constitute the formation of a Contract, until the Contract has been affected pursuant to signing of Contract as per "ITB: Clause-37".

Upon the successful Bidder's / Contractor's furnishing of 'Contract Performance Security / Security Deposit', pursuant to "ITB: Clause-38", TFL will promptly discharge his 'Earnest Money / Bid Security', pursuant to "ITB: Clause-16"

36.3 The Order/ contract value mentioned above is subject to Mutually Agreed Damages clause.

**37 **SIGNING OF AGREEMENT

37.1 OWNER will award the Contract to the successful Bidder, who, within 'fifteen [15] days' of issuance of the same, shall sign and return the acknowledged copy to OWNER.

37.2 The successful Bidder/Contractor shall be required to execute 'Contract Agreement' in the prescribed format given in this Tender Document (Form F-11) on a 'non-judicial stamp paper' of appropriate value [cost of the 'stamp-paper' shall be borne by the successful Bidder/Contractor] and of 'state' specified in Bidding Data Sheet (BDS) only, within 'fifteen [15] days' of issuance of "Notification of Award i.e. Fax of Acceptance (FOA)" of the Tender by the successful Bidder/Contractor. Failure on the part of the successful Bidder/Contractor to sign the 'Agreement' within the above stipulated period, shall constitute sufficient grounds for forfeiture of EMD/Security Deposit.

**38 **CONTRACT PERFORMANCE SECURITY / SECURITY DEPOSIT

38.1 Within 30 days of the issuance of Notification of Award i.e. Fax of Acceptance (FOA) by OWNER, the successful bidder shall furnish the Contract Performance Security
(CPS). The CPS shall be in the form of either Banker’s Cheque or Demand Draft or Bank Guarantee as per Format “F-4” and shall be in the currency of the Contract.

38.2 The CONTRACT PERFORMANCE SECURITY shall be for an amount equal to 10% of total contract value towards faithful performance of the contractual obligations and performance of equipment. For the purpose of CPS, Contract/order value shall be exclusive of GST (CGST & SGST/UTGST or IGST) to be reimbursed by the Owner.

Bank Guarantee towards CPS shall be from any Indian scheduled bank or a branch of an International bank situated in India and registered with Reserve Bank of India as scheduled foreign bank in case of Indian bidder as well as foreign bidder. However, in case of bank guarantees from banks other than the Nationalized Indian banks, the bank must be a commercial bank having net worth in excess of Rs 100 crores and a declaration to this effect should be made by such commercial bank either in the Bank Guarantee itself or separately on its letterhead. This bank guarantee shall be valid for a period as three months beyond the DLP (Defect Liability Period) specified in Special Conditions of Contract (SCC).

38.3 Failure of the successful bidder to comply with the requirements of this article shall constitute sufficient grounds for the annulment of the award and forfeiture of the EMD.

38.4 CPBG/Security Deposit will not be accepted in case the same has reference of ‘remitter’ / ‘financer’ other than bidder on the aforementioned financial instrument of CPBG/ Security.

38.5 The CPS has to cover the entire contract value including extra works also. As long as the CPS submitted at the time of award takes cares the extra works executed and total executed value are within the awarded contract price, there is no need for additional CPS. As soon as the total executed value is likely to burst the ceiling of awarded contract price, the contractor should furnish additional CPS.

38.6 In case of forfeiture of Contract Performance Security/ Security Deposit, the forfeited amount will be considered inclusive of tax and tax invoice will be issued by TFL. The forfeiture amount will be subject to final decision of TFL based on other terms and conditions of order/ contract.

38.7 Please also refer 8.0 of GCC of NIT

39 PROCEDURE FOR ACTION IN CASE CORRUPT/FRAUDULENT/COLLUSIVE/ COERCIVE PRACTICES

39.1 Procedure for action in case Corrupt/ Fraudulent/Collusive/Coercive Practices is provided at Annexure-I

39.2 NON-APPLICABILITY OF ARBITRATION CLAUSE IN CASE OF BANNING OF VENDORS/ SUPPLIERS / CONTRACTORS/ BIDDERS/ CONSULTANTS INDULGED IN FRAUDULENT/ COERCIVE PRACTICES

Notwithstanding anything contained contrary in GCC and other "CONTRACT DOCUMENTS", in case it is found that the Vendors/ Suppliers / Contractors/ Bidders/ Consultants indulged in fraudulent/ coercive practices at the time of bidding, during execution of the contract etc. and/or on other grounds as mentioned in OWNER’s "Procedure for action in case Corrupt/Fraudulent/Collusive/Coercive Practices" (Annexure-I), the contractor/bidder shall be banned (in terms of aforesaid procedure) from the date of issuance of such order by OWNER, to such Vendors/ Suppliers / Contractors/Bidders/ Consultants.
The Vendor/Supplier/Contractor/Bidder/Consultant understands and agrees that in such cases where Vendor/Supplier/Contractor/Bidder/Consultant has been banned (in terms of aforesaid procedure) from the date of issuance of such order by OWNER, such decision of OWNER shall be final and binding on such Vendor/Supplier/Contractor/Bidder/Consultant and the ‘Arbitration clause’ in the GCC and other “CONTRACT DOCUMENTS” shall not be applicable for any consequential issue/dispute arising in the matter.

40 **PUBLIC PROCUREMENT POLICY FOR MICRO AND SMALL ENTERPRISES**

40.1 Following provision has been incorporated in tender for MSEs, in line with notification of Government of India, vide Gazette of India No. 503 dated 26.03.2012 proclaiming the Public Procurement Policy on procurement of goods and services from Micro and Small Enterprises (MSEs)

i) Issue of tender document to MSEs free of cost.
ii) Exemption to MSEs from payment of EMD/Bid Security.

40.2 In case bidder is a Micro or Small Enterprise under the Micro, Small and Medium Enterprises Development Act, 2006, the bidder shall submit the following:

- Documentary evidence that the bidder is a Micro or Small Enterprises registered with District Industries Centers or Khadi and Village Industries National Small Industries Corporation or Directorate of Handicrafts and Handloom or any other body specified by Ministry of Micro, Small and Medium Enterprises or Udyog Aadhaar Memorandum.

The above documents submitted by the bidder shall be duly certified by the Chartered Accountant (not being an employee or a Director or not having any interest in the bidder’s company/firm) and notary public with legible stamp.

If the bidder does not provide the above confirmation or appropriate document or any evidence, then it will be presumed that they do not qualify for any preference admissible in the Public Procurement Policy (PPP) 2012.

Further, MSEs who are availing the benefits of the Public Procurement Policy (PPP) 2012 get themselves registered with MSME Data Bank being operated by NSIC, under SME Division, M/o MSME, in order to create proper data base of MSEs which are making supplies to CPSUs.

40.3 If against an order placed by OWNER, successful bidder(s) (other than Micro/Small Enterprise) is procuring material/services from their sub-vendor who is a Micro or Small Enterprise registered with District Industries Centers or Khadi and Village Industries Commission or Khadi and Village Industries Board or Coir Board or National Small Industries Corporation or Directorate of Handicrafts and Handloom or any other body specified by Ministry of Micro, Small and Medium Enterprises with prior consent in writing of the purchasing authority/Engineer-in-charge, the details like Name, Registration No., Address, Contact No. details of material & value of procurement made, etc. of such Enterprises shall be furnished by the successful bidder at the time of submission of invoice/Bill.

40.4 The benefit of policy are not extended to the traders/dealers/Distributors/Stockiest/Wholesalers.
40.5 NSIC has initiated a scheme of “Consortia and Tender Marketing Scheme” under which they are assisting the Micro & Small enterprises to market their products and services through tender participation on behalf of the individual unit or through consortia.

Accordingly, if the MSEs or the consortia, on whose behalf the bid is submitted by NSIC, is meeting the BEC and other terms and conditions of tender their bid will be considered for further evaluation.

Further, in such cases a declaration is to be submitted by MSE/ consortia on their letter head(s) that all the terms and conditions of tender document shall be acceptable to them.

41 DELETED

42 VENDOR PERFORMANCE EVALUATION

Shall be as stipulated Annexure II to ITB herewith.

43 INCOME TAX & CORPORATE TAX

43.1 Income tax deduction shall be made from all payments made to the contractor as per the rules and regulations in force and in accordance with the Income Tax Act prevailing from time to time.

43.2 Corporate Tax liability, if any, shall be to the contractor’s account.

43.3 TDS, wherever applicable, shall be deducted as per applicable act/law/rule.

43.4 MENTIONING OF PAN NO. IN INVOICE/BILL

As per CBDT Notification No. 95/2015 dated 30.12.2015, mentioning of PAN no. is mandatory for procurement of goods / services/works/consultancy services exceeding Rs. 2 Lacs per transaction.

Accordingly, supplier/ contractor/ service provider/ consultant should mention their PAN no. in their invoice/ bill for any transaction exceeding Rs. 2 lakhs. As provided in the notification, in case supplier/ contractor/ service provider/ consultant do not have PAN no., they have to submit declaration in Form 60 along with invoice/ bill for each transaction.

Payment of supplier/ contractor / service provider/ consultant shall be processed only after fulfilment of above requirement

44. SETTLEMENT OF COMMERCIAL DISPUTES BETWEEN PUBLIC SECTOR ENTERPRISE(S) INTER SE AND PUBLIC SECTOR ENTERPRISE(S) AND GOVERNMENT DEPARTMENT(S) THROUGH ADMINISTRATIVE MECHANISM FOR RESOLUTION OF CPSES DISPUTES (AMRCD) IN THE DEPARTMENT OF PUBLIC ENTERPRISES

In the event of any dispute or difference relating to the interpretation and application of the provisions of commercial contract(s)between Central Public Sector Enterprises (CPSEs) inter se and also between CPSEs and Government Departments / Organizations (excluding disputes concerning Railways, Income Tax, Customs & Excise Departments), such dispute or difference shall be taken up by either party for
45. **DISPUTE RESOLUTION MECHANISM**

1.0 **CONCILIATION**

Where invitation for Conciliation has been accepted by the other party, the Parties shall attempt to settle such dispute(s) amicably under Part-III of the Arbitration and Conciliation Act, 1996. It would be only after exhausting the option of Conciliation as an Alternate Dispute Resolution Mechanism that the Parties hereto shall invoke Arbitration Clause. For the purpose of this clause, the option of ‘Conciliation’ shall be deemed to have been exhausted, even in case of rejection of ‘Conciliation’ by any of the Parties.

2.0 **ARBITRATION**

All issue(s)/dispute(s) excluding the matters that have been specified as excepted matters and listed at clause no. 2.6 and which cannot be resolved through Conciliation, such issue(s)/dispute(s) shall be referred to arbitration for adjudication by Sole Arbitrator.

The party invoking the Arbitration shall have the option to either opt for Ad-hoc Arbitration as provided at Clause 2.1 below or Institutionalized Arbitration as provided at Clause 2.2 below, the remaining clauses from 2.3 to 2.7 shall apply to both Ad-hoc and Institutional Arbitration:-

2.1 On invocation of the Arbitration clause by either party, TFL shall suggest a panel of three independent and distinguished persons (Retd Supreme Court & High Court Judges only) to the other party from the Panel of Arbitrators maintained by ‘Delhi International Arbitration Centre (DIAC) to select any one among them to act as the Sole Arbitrator. In the event of failure of the other party to select the Sole Arbitrator within 30 days from the receipt of the communication from TFL suggesting the panel of arbitrators, the right of selection of the sole arbitrator by the other party shall stand forfeited and TFL shall appoint the Sole Arbitrator from the suggested panel of three Arbitrators for adjudication of dispute(s). The decision of TFL on the appointment of the sole arbitrator shall be final and binding on the other party. The fees payable to Sole Arbitrator shall be governed by the fee Schedule of “Delhi International Arbitration Centre”.

OR

2.2 If a dispute arises out of or in connection with this contract, the party invoking the Arbitration shall submit that dispute to any one of the Arbitral Institutions i.e ICADR/ICA/DIAC/SFCA and that dispute shall be adjudicated in accordance with their respective Arbitration Rules. The matter shall be adjudicated by a Sole Arbitrator who shall necessarily be a Retd Supreme Court/High Court Judge to be appointed/nominated by the respective institution. The cost/expenses pertaining to the said Arbitration shall also be governed in accordance with the Rules of the respective Arbitral Institution. The decision of the party invoking the Arbitration for reference of dispute to a specific Arbitral institution for adjudication of that dispute shall be final and binding on both the parties and shall not be subject to any change thereafter. The institution once selected at the time of invocation of dispute shall remain unchanged.
2.3 The cost of arbitration proceedings shall be shared equally by the parties.

2.4 The Arbitration proceedings shall be in English language and the seat, venue and place of Arbitration shall be New Delhi, India only.

2.5 Subject to the above, the provisions of Arbitration & Conciliation Act 1996 and any amendment thereof shall be applicable. All matter relating to this Contract and arising out of invocation of Arbitration clause are subject to the exclusive jurisdiction of the Court(s) situated at New Delhi.

2.6 List of Excepted matters:
   a) Dispute(s)/issue(s) involving claims below Rs 25 lakhs and above Rs 25 crores.
   b) Dispute(s)/issue(s) relating to indulgence of Contractor/Vendor/Bidder in corrupt/fraudulent/collusive/coercive practices and/or the same is under investigation by CBI or Vigilance or any other investigating agency or Government.
   c) Dispute(s)/issue(s) wherein the decision of Engineer-In-Charge/owner/TFL has been made final and binding in terms of the Contract.

2.7. Disputes involving claims below Rs 25 Lakhs and above Rs. 25 crores:- Parties mutually agree that dispute(s)/issue(s) involving claims below Rs 25 Lakhs and above Rs 25 crores shall not be subject matter of Arbitration and are subject to the exclusive jurisdiction of the Court(s) situated at New Delhi.

3.0 GOVERNING LAW AND JURISDICTION:

The Contract shall be governed by and construed in accordance with the laws in force in India. The Parties hereby submit to the exclusive jurisdiction of the Courts situated at New Delhi for adjudication of disputes, injunctive reliefs, actions and proceedings, if any, arising out of this Contract.

4.0 DISPUTES BETWEEN CPSE’S/ GOVERNMENT DEPARTMENT’S/ORGANIZATIONS

Subject to conciliation as provided above, in the event of any dispute or difference relating to the interpretation and application of the provisions of commercial contract(s) between Central Public Sector Enterprises (CPSEs)/ Port Trusts inter se and also between CPSEs and Government Departments /Organizations (excluding disputes concerning Railways, Income Tax, Customs & Excise Departments), such dispute or difference shall be taken up by either party for resolution through AMRCD as mentioned in OPE OM No. 4(1)/2013-DPE(GM)/FTS-1835 dated 22-05-2018.

Any party aggrieved with the decision of the Committee at the First level (tier) may prefer an appeal before the Cabinet Secretary at the Second level (tier) within 15 days from the date of receipt of decision of the Committee at First level, through it's administrative Ministry/Department, whose decision will be final and binding on all concerned.

The above provisions mentioned at clause no. 45 shall supersede provisions relating to Conciliation, Arbitration, Governing Law & Jurisdiction and Disputes between CPSE’s/ Government Department’s/ Organizations mentioned in General Conditions of Contract (GCC) and elsewhere in tender document.
PROMOTION OF PAYMENT THROUGH CARDS AND DIGITAL MEANS
To promote cashless transactions, the onward payments by Contractors to their employees, service providers, sub-contractors and suppliers may be made through Cards and Digital means to the extent possible.

CONTRACTOR TO ENGAGE CONTRACT MANPOWER BELONGING TO SCHEDULED CASTES AND WEAKER SECTIONS OF THE SOCIETY
While engaging the contractual manpower, Contractors are required to make efforts to provide opportunity of employment to the people belonging to Scheduled Castes and weaker sections of the society also in order to have a fair representation of these sections.

QUARTERLY CLOSURE OF THE CONTRACT [FOR APPLICABILITY OF THIS CLAUSE REFER BDS]-
During execution of contracts/orders, various issues may arise. In order to timely detect and to address the contractual issue(s) during the execution of contracts, OWNER has introduced a mechanism of quarterly closure of the contract, under which all the issues related to the contract execution will be monitored on quarterly basis for resolution.

Vendors/Contractors are required to co-operate with EIC for proper implementation of this mechanism for smooth execution of the contract.

PROVISIONS FOR STARTUPS (AS DEFINED IN GAZETTE NOTIFICATION NO. D.L-33004/99 DATED 18.02.2016 AND 23.05.2017 OF MINISTRY OF COMMERCE AND INDUSTRY AND AS AMENDED FROM TIME TO TIME) [FOR APPLICABILITY REFER BDS]
As mentioned in Section-II, Prior turnover and prior experience shall be required for all Startups [whether Micro & Small Enterprises (MSEs) or otherwise] subject to their meeting the quality and technical specifications specified in tender document.

Further, the Startups are also exempted from submission of EMDs.

If a Startup emerge lowest bidder, the DLOA on such Startup shall be placed for entire tendered quantity/group/item/part (as the case may be). However, during the Kick of Meeting monthly milestones/ check points would be drawn. Further, the performance of such contractor/ service provider will be reviewed more carefully and action to be taken as per provision of contract in case of failure/ poor performance.

PROVISION REGARDING INVOICE FOR REDUCED VALUE OR CREDIT NOTE TOWARDS MAD (MUTUALLY AGREED DAMAGES)
As mentioned in GCC, MAD is the reduction in the consideration / contract value for the goods / services covered under this contract. In case of delay in supply/ execution of contract, supplier/ contractor/ service provider should raise invoice for reduced value as per MAD clause. If supplier/ contractor/ service provider has raised the invoice for full value, then supplier/ contractor/ service provider should issue Credit Note towards the applicable MAD amount with applicable taxes.
In such cases if supplier/ contractor/ service provider fails to submit the invoice with reduced value or does not issue credit note as mentioned above, OWNER will release the payment to supplier/ contractor/ service provider after giving effect of the MAD clause with corresponding reduction of taxes charged on vendor’s invoice, to avoid delay in delivery/collection of material."

In case any financial implication arises on OWNER due to issuance of invoice without reduction in price or non-issuance of Credit Note, the same shall be to the account of supplier/ contractor/ service provider. OWNER shall be entitled to deduct / setoff / recover such GST amount (CGST & SGST/UTGST or IGST) together with penalties and interest, if any, against any amounts paid or becomes payable by OWNER in future to the Supplier/Contractor under this contract or under any other contract.

52 POLICY TO PROVIDE PURCHASE PREFERENCE (LINKED WITH LOCAL CONTENT) (PP-LC)

The policy for providing purchase preference (linked with Local content) is enclosed as Annexure V to ITB herewith.
Annexure-I

PROCEDURE FOR ACTION IN CASE CORRUPT/FRAUDULENT/COLLUSIVE/COERCIVE PRACTICES

A Definitions:

A.1 “Corrupt Practice” means the offering, giving, receiving or soliciting, directly or indirectly, anything of value to improperly influence the actions in selection process or in contract execution.

“Corrupt Practice” also includes any omission for misrepresentation that may mislead or attempt to mislead so that financial or other benefit may be obtained or an obligation avoided.

A2 “Fraudulent Practice” means and include any act or omission committed by an agent or with his connivance or by his agent by misrepresenting/submitting false documents and/or false information or concealment of facts or to deceive in order to influence a selection process or during execution of contract/order.

A3 “Collusive Practice amongst bidders (prior to or after bid submission)” means a scheme or arrangement designed to establish bid prices at artificial non-competitive levels and to deprive the Employer of the benefits of free and open competition.

A4 “Coercive practice” means impairing or harming or threatening to impair or harm directly or indirectly, any agency or its property to influence the improperly actions of an agency, obstruction of any investigation or auditing of a procurement process.

A5 “Vendor/Supplier/Contractor/Consultant/Bidder” is herein after referred as “Agency”

A.6 “Appellate Authority” shall mean Committee of Directors consisting of Director (Finance) and Director (BD) for works centers under Director (Projects). For all other cases committee of Directors shall consist of Director (Finance) & Director (Projects).

A.7 “Competent Authority” shall mean the authority, who is competent to take final decision for Suspension of business dealing with an Agency/ies and Banning of business dealings with Agency/ies and shall be the “Director” concerned.

A.8 “Allied Agency” shall mean all the concerns within the sphere of effective influence of banned/suspended agencies. In determining this, the following factors may be taken into consideration:

(a) Whether the management is common;
(b) Majority interest in the management is held by the partners or directors of banned/suspended firm.
(c) Substantial or majority shares are owned by banned/suspended agency and by virtue of this it has a controlling voice.

A.9 “Investigating Agency” shall mean any department or unit of TFL investigating into the conduct of Agency/party and shall include the Vigilance Department of the TFL, Central Bureau of Investigation, State Police or any other agency set up by the Central or state government having power to investigate.

B Actions against bidder(s) indulging in corrupt/fraudulent/collusive/coercive practice
B.1 Irregularities noticed during the evaluation of the bids:

If it is observed during bidding process/bids evaluation stage that a bidder has indulged in corrupt/fraudulent/collusive/coercive practice, the bid of such Bidder(s) shall be rejected and its Earnest Money Deposit (EMD) shall be forfeited.

Further, such agency shall be banned for future business with TFL for a period specified in para B.2.2 below from the date of issue of banning order.

B.2 Irregularities noticed after award of contract

(i) During execution of contract:

If an agency, is found to have indulged in corrupt/fraudulent/collusive/coercive practices, during execution of contract, the agency shall be banned for future business with TFL for a period specified in para B.2.2 below from the date of issue of banning order.

The concerned order(s)/contract(s) where corrupt/fraudulent/collusive practices is observed, shall be suspended with immediate effect by Engineer-in-Charge (EIC)/Employer whereby the supply/work/service and payment etc. will be suspended. The action shall be initiated for putting the agency on banning.

After conclusion of process, the order(s)/contract(s) where it is concluded that such irregularities have been committed shall be terminated and Contract cum Performance Bank Guarantee (CPBG)/Contract Performance Security (CPS) submitted by agency against such order(s)/contract(s) shall also be forfeited. The amount that may have become due to the contractor on account of work already executed by him shall be payable to the contractor and this amount shall be subject to adjustment against any amounts due from the contractor under the terms of the contract.

No risk and cost provision will be enforced in such cases.

(ii) After execution of contract and during Defect liability period (DLP)/Warranty/Guarantee Period:

If an agency is found to have indulged in corrupt/fraudulent/collusive/coercive practices, after execution of contract and during DLP/Warranty/Guarantee Period, the agency shall be banned for future business with TFL for a period specified in para B.2.2 below from the date of issue of banning order.

Further, the Contract cum Performance Bank Guarantee (CPBG)/Contract Performance Security (CPS) submitted by agency against such order(s)/contract(s) shall be forfeited.

(iii) After expiry of Defect liability period (DLP)/Warranty/Guarantee Period:

If an agency is found to have indulged in corrupt/fraudulent/collusive/coercive practices, after expiry of Defect liability period (DLP)/Warranty/Guarantee Period, the agency shall be banned for future business with TFL for a period specified in para B.2.2 below from the date of issue of banning order.

B.2.2 Period of Banning
The period of banning of agencies indulged in Corrupt/ Fraudulent/ Collusive/Coercive Practices shall be as under and to be reckoned from the date of banning order:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>Period of banning from the date of issuance of Banning order</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Misrepresentation/False information other than pertaining to BEC of tender but having impact on the selection process. For example, if an agency confirms not being in holiday/ banning list of PSUs/ Govt. Dept., liquidation, bankruptcy &amp; etc. and subsequently it is found otherwise, such acts shall be considered in this category.</td>
<td>02 years</td>
</tr>
<tr>
<td>2</td>
<td>Corrupt/Fraudulent (pertaining to BEC of tender) /Collusive/Coercive Practices</td>
<td>03 years</td>
</tr>
<tr>
<td>2.1</td>
<td>If an agency again commits Corrupt/Fraudulent (pertaining to BEC of tender) /Collusive/ Coercive Practices in subsequent cases after their banning, such situation of repeated offense to be dealt with more severity and following shall be the period of banning: (i) Repeated once (ii) Repeated twice or more</td>
<td>7 years (in addition to the period already served) 15 years (in addition to the period already served)</td>
</tr>
<tr>
<td>3</td>
<td>Indulged in unauthorized disposal of materials provided by TFL</td>
<td>7 years</td>
</tr>
<tr>
<td>4</td>
<td>If act of vendor/ contractor is a threat to the National Security</td>
<td>15 years</td>
</tr>
</tbody>
</table>

C Effect of banning on other ongoing contracts/ tenders

C.1 If an agency is put on Banning, such agency should not be considered in ongoing tenders/future tenders.

C.2 However, if such an agency is already executing other order (s)/ contract (s) where no corrupt/fraudulent/ collusive/coercive practice is found, the agency should be allowed to continue till its completion without any further increase in scope except those incidental to original scope mentioned in the contract.

C.3 If an agency is put on the Banning List during tendering and no irregularity is found in the case under process:

C.3.1 after issue of the enquiry /bid/tender but before opening of Technical bid, the bid submitted by the agency shall be ignored.

C.3.2 after opening Technical bid but before opening the Price bid, the Price bid of the agency shall not be opened and BG/EMD submitted by the agency shall be returned to the agency.
C.3.3 after opening of price, BG/EMD made by the agency shall be returned; the offer of the agency shall be ignored & will not be further evaluated. If the agency is put on banning list for fraud/ mis-appropriation of facts committed in the same tender/other tender where errant agency emerges as the lowest (L1), then such tender shall also be cancelled and re-invited.

D. Procedure for Suspension of Bidder

D.1 Initiation of Suspension

Action for suspension business dealing with any agency(ies) shall be initiated by Corporate C&P Department when

(i) Corporate Vigilance Department based on the fact of the case gathered during investigation by them recommend for specific immediate action against the agency.

(ii) Corporate Vigilance Department based on the input from Investigating agency, forward for specific immediate action against the agency.

(iii) Non performance of Vendor/Supplier/Contractor/Consultant leading to termination of Contract/Order.

D.2 Suspension Procedure:

D.2.1 The order of suspension would operate initially for a period not more than six months and is to be communicated to the agency and also to Corporate Vigilance Department. Period of suspension can be extended with the approval of the Competent Authority by one month at a time with a ceiling of six months pending a conclusive decision to put the agency on banning list.

D.2.2 During the period of suspension, no new business dealing may be held with the agency.

D.2.3 Period of suspension shall be accounted for in the final order passed for banning of business with the agency.

D.2.4 The decision regarding suspension of business dealings should also be communicated to the agency.

D.2.5 If a prima-facie, case is made out that the agency is guilty on the grounds which can result in banning of business dealings, proposal for issuance of suspension order and show cause notice shall be put up to the Competent Authority. The suspension order and show cause notice must include that (i) the agency is put on suspension list and (ii) why action should not be taken for banning the agency for future business from TFL.

The competent authority to approve the suspension will be same as that for according approval for banning.

D 3 Effect of Suspension of business:

Effect of suspension on other on-going/future tenders will be as under:
D.3.1 No enquiry/bid/tender shall be entertained from an agency as long as the name of agency appears in the Suspension List.

D.3.2 If an agency is put on the Suspension List during tendering:

D.3.2.1 after issue of the enquiry /bid/tender but before opening of Technical bid, the bid submitted by the agency shall be ignored.

D.3.2.2 after opening Technical bid but before opening the Price bid, the Price bid of the agency shall not be opened and BG/EMD submitted by the agency shall be returned to the agency.

D.3.2.3 after opening of price, BG/EMD made by the agency shall be returned; the offer of the agency shall be ignored & will not be further evaluated. If the agency is put on Suspension list for fraud/ mis-appropriation of facts conducted in the same tender/other tender where errant agency emerges as the lowest (L1), then such tender shall also be cancelled and re-invited.

D.3.3 The existing contract (s)/ order (s) under execution shall continue.

D.3.4 Tenders invited for procurement of goods, works and services shall have provision that the bidder shall submit a undertaking to the effect that (i) neither the bidder themselves nor their allied agency/(ies) are on banning list of TFL and (ii) bidder is not banned by any Government department/ Public Sector.

F. Appeal against the Decision of the Competent Authority:

F.1 The agency may file an appeal against the order of the Competent Authority for putting the agency on banning list. The appeal shall be filed to Appellate Authority. Such an appeal shall be preferred within one month from the of receipt of banning order.

F.2 Appellate Authority would consider the appeal and pass appropriate order which shall be communicated to the party as well as the Competent Authority.

F.3 Appeal process may be completed within 45 days of filing of appeal with the Appellate Authority.

G. Wherever there is contradiction with respect to terms of ‘Integrity pact’ , GCC and ‘Procedure for action in case of Corrupt/Fraudulent/ Collusive/Coercive Practice’, the provisions of ‘Procedure for action in case of Corrupt/Fraudulent/ Collusive/Coercive Practice’ shall prevail.
PROCEDURE FOR EVALUATION OF PERFORMANCE OF VENDORS/ SUPPLIERS/ CONTRACTORS/ CONSULTANTS

1.0 OBJECTIVE

The objective of Evaluation of Performance aims to recognize, and develop reliable Vendors/ Suppliers/Contractors/ Consultants so that they consistently meet or exceed expectations and requirements.

The purpose of this procedure is to put in place a system to monitor performance of Vendors/ Suppliers/Contractors/ Consultants to ensure timely completion of various projects, timely receipt of supplies including completion of works & services for operation and maintenance of operating plants and quality standards in all respects.

2.0 METHODOLOGY

i) Preparation of Performance Rating Data Sheet

Performance rating data Sheet for each and every Vendor/ Supplier/Contractor/Consultant for all orders/Contracts with a value of Rs. 50 Lakhs and above is recommended to be drawn up. Further, Performance rating data Sheet for orders/contracts of Vendor/Supplier/Contractor/ Consultant who are on watch list/holiday list/ banning list shall be prepared irrespective of order/ contract value. These data sheets are to be separately prepared for orders/ contracts related to Projects and O&M. Format, Parameters, Process, responsibility for preparation of Performance Rating Data Sheet are separately mentioned.

ii) Measurement of Performance

Based on the parameters defined in Data Sheet, Performance of concerned Vendor/ Supplier/Contractor/ Consultant would be computed and graded accordingly. The measurement of the performance of the Party would be its ability to achieve the minimum scoring of 60% points in the given parameters.

iii) Initiation of Measures:

Depending upon the Grading of Performance, corrective measures would be initiated by taking up the matter with concerned Vendor/ Supplier/Contractor/ Consultant. Response of Vendor/ Supplier/Contractor/ Consultant would be considered before deciding further course of action.

iv) Implementation of Corrective Measures:

Based on the response of Vendor/ Supplier/Contractor/ Consultant, concerned Engineer-in-Charge would recommend for continuation or discontinuation of such party from the business of TFL.

v) Orders/contracts placed on Proprietary/OEM basis for O&M will be evaluated and, if required, corrective action will be taken for improvement in future.
3.0 **PROCESS OF EVALUATION OF PERFORMANCE OF VENDORS/ SUPPLIERS/ CONTRACTORS/ CONSULTANTS**

3.1 **FOR PROJECTS**

i) Evaluation of performance of Vendors/ Suppliers/Contractors/ Consultants in case of PROJECTS shall be done immediately with commissioning of any Project.

ii) On commissioning of any Project, EIC (Engineer-in-charge)/ Project-in-charge shall prepare a Performance Rating Data Sheet (Format at Annexure-1) for all Orders and Contracts.

iii) Depending upon the Performance Rating, following action need to be initiated by Engineer-in-charge/Project-in-charge:

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Performance Rating</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>POOR</td>
<td>Seek explanation for Poor performance</td>
</tr>
<tr>
<td>2</td>
<td>FAIR</td>
<td>Seek explanation for Fair performance</td>
</tr>
<tr>
<td>3</td>
<td>GOOD</td>
<td>Letter to the concerned for improving performance in future</td>
</tr>
<tr>
<td>4</td>
<td>VERY GOOD</td>
<td>No further action</td>
</tr>
</tbody>
</table>

iv) Reply from concerned Vendor/ Supplier/Contractor/ Consultant shall be examined. In case of satisfactory reply, Performance Rating data Sheet to be closed with a letter to the concerned for improving performance in future.

v) When no reply is received or reasons indicated are unsatisfactory, the following actions need to be taken:

A) Where performance rating is “POOR” (as per Performance Rating carried out after execution of Order/ Contract and where no reply/ unsatisfactory reply is received from party against the letter seeking the explanation from Vendor/Supplier/Contractor/ Consultant along with sharing the performance rating)

Recommend such defaulting Vendor/Supplier/Contractor/ Consultant for the following action:

(a) **First such instance: Advisory notice (Yellow Card)** shall be issued and Vendor/Supplier/Contractor/ Consultant shall be put on watch list for a period of Three (3) Years. Such vendor will be allowed to participate in all other tenders and to execute other ongoing order/ contract (s) or new contract/ order (s).

The Yellow card will be automatically revoked after a period of three years unless the same is converted into Red Card due to subsequence instances of poor/ non-performance in other ongoing order (s)/ contract (s) or new order (s) /contract (s) on such Vendor/ Supplier/ Contractor/ Consultant.
(b) **Second such instance in other ongoing order (s)/ contract (s) or new order (s) /contact (s) on such Vendor/ Supplier/ Contractor/ Consultant**

(i) Poor Performance due to reasons other than Quality:  
**Putting on Holiday for a period of One Year**

(ii) Poor Performance on account of Quality (if any mark obtained against Quality parameter is less than 30):  
**Putting on Holiday for a period of Two Years**

(c) **Subsequent instances (more than two) in other ongoing order (s)/ contract (s) or new order (s) /contact (s) on such Vendor/ Supplier/ Contractor/ Consultant:**  
**Putting on Holiday for a period of Three Years**

B) Where Poor/Non-Performance leading to termination of contract or Offloading of contract due to poor performance attributable to Vendor/Supplier/ Contractor/Consultant (under Clause no.3.16.1 of GCC- Consultancy)

(a) **First instance:** **Advisory notice (Yellow Card) shall be issued and Vendor/Supplier/Contractor /Consultant shall be put on watch list for a period of Three (3) Years.** Further such vendor will not be allowed to participate in the re-tender of the same supply/work/services of that location which has terminated / offloaded. Moreover, it will be ensured that all other action as per provision of contract including forfeiture of Contract Performance Security (CPS) etc. are undertaken. However, such vendor will be allowed to participate in all other tenders and to execute other ongoing order/ contract (s) or new contract/ order (s).

The Yellow card will be automatically revoked after a period of three years unless the same is converted into Red Card due to subsequent instances of poor/ non-performance in other ongoing order (s)/ contract (s) or new order (s) /contact (s) on such Vendor/ Supplier/ Contractor/ Consultant.

(b) **Second instances** in other ongoing order (s)/ contract (s) or new order (s) /contact (s) on such Vendor/ Supplier/ Contractor/ Consultant: **Holiday (Red Card)** for period of One Year and they shall also to be considered for Suspension.

(c) **Subsequent instances (more than two) in other ongoing order (s)/ contract (s) or new order (s) /contact (s) on such Vendor/ Supplier/ Contractor/ Consultant:** **Holiday (Red Card)** for period of Three Years and they shall also to be considered for Suspension.

(C) **Where Performance rating is “FAIR”:**  
Issuance of warning to such defaulting Vendor/ Supplier/Contractor/ Consultant to improve their performance.

3.2 **FOR CONSULTANCY JOBS**

Monitoring and Evaluation of consultancy jobs will be carried out in the same way as described in para 3.1 for Projects.
3.3 FOR OPERATION & MAINTENANCE


ii) After execution of orders a Performance Rating Data Sheet (Format at Annexure-2) shall be prepared for Orders by C&P and for Contracts/Services by respective Engineer-In-Charge.

iii) Depending upon Performance Rating, following action need to be initiated by C&P:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Performance Rating</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>POOR</td>
<td>Seek explanation for Poor performance</td>
</tr>
<tr>
<td>2</td>
<td>FAIR</td>
<td>Seek explanation for Fair performance</td>
</tr>
<tr>
<td>3</td>
<td>GOOD</td>
<td>Letter to the concerned for improving performance in future.</td>
</tr>
<tr>
<td>4</td>
<td>VERY GOOD</td>
<td>No further action</td>
</tr>
</tbody>
</table>

iv) Reply from concerned Vendor/ Supplier/Contractor/ Consultant shall be examined. In case of satisfactory reply, Performance Rating data Sheet to be closed with a letter to the concerned for improving performance in future.

v) When no reply is received or reasons indicated are unsatisfactory, the following actions need to be taken:

A) Where performance rating is “POOR” (as per Performance Rating carried out after execution of Order/ Contract and where no reply/ unsatisfactory reply is received from party against the letter seeking the explanation from Vendor/Supplier/Contractor/ Consultant along with sharing the performance rating)

Recommend such defaulting Vendor/Supplier/Contractor/ Consultant for the following action:

(b) First such instance: Advisory notice (Yellow Card) shall be issued and Vendor/Supplier/Contractor/ Consultant shall be put on watch list for a period of Three (3) Years.
Such vendor will be allowed to participate in all other tenders and to execute other ongoing order/ contract (s) or new contract/ order (s).

The Yellow card will be automatically revoked after a period of three years unless the same is converted into Red Card due to subsequence instances of poor/ non-performance in other ongoing order (s)/ contract (s) or new order (s)/contract (s) on such Vendor/ Supplier/ Contractor/ Consultant.

(b) Second such instance in other ongoing order (s)/ contract (s) or new order (s)/contract (s) on such Vendor/ Supplier/ Contractor/ Consultant
(i) Poor Performance due to reasons other than Quality: Putting on Holiday for a period of One Year
(ii) Poor Performance on account of Quality (if any mark obtained against Quality parameter is less than 30):

**Putting on Holiday for a period of Two Years**

(c) Subsequent instances (more than two) in other ongoing order (s)/ contract (s) or new order (s) /contact (s) on such Vendor/ Supplier/ Contractor/ Consultant: **Putting on Holiday for a period of Three Years**

B) Where Poor/Non-Performance leading to termination of contract or Offloading of contract due to poor performance attributable to Vendor/Supplier/ Contractor/Consultant (under Clause no.3.16.1 of GCC- Consultancy)

(d) First instance: Advisory notice (Yellow Card) shall be issued and Vendor/Supplier/Contractor /Consultant shall be put on watch list for a period of Three (3) Years. Further such vendor will not be allowed to participate in the re-tender of the same supply/work/services of that location which has terminated / offloaded. Moreover, it will be ensured that all other action as per provision of contract including forfeiture of Contract Performance Security (CPS) etc. are undertaken. However, such vendor will be allowed to participate in all other tenders and to execute other ongoing order/ contract (s) or new contract/ order (s). The Yellow card will be automatically revoked after a period of three years unless the same is converted into Red Card due to subsequence instances of poor/ non-performance in other ongoing order (s)/ contract (s) or new order (s) /contact (s) on such Vendor/ Supplier/ Contractor/ Consultant.

(e) Second instances in other ongoing order (s)/ contract (s) or new order (s) /contact (s) on such Vendor/ Supplier/ Contractor/ Consultant: **Holiday (Red Card)** for period of One Year and they shall also to be considered for Suspension.

(f) Subsequent instances (more than two) in other ongoing order (s)/ contract (s) or new order (s) /contact (s) on such Vendor/ Supplier/ Contractor/ Consultant: **Holiday (Red Card)** for period of Three Years and they shall also to be considered for Suspension.

(C) Where Performance rating is “FAIR”:

Issuance of warning to such defaulting Vendor/ Supplier/Contractor/ Consultant to improve their performance.

4.0 **EXCLUSIONS:**

The following would be excluded from the scope of evaluation of performance of Vendors/ Suppliers/Contractors/ Consultants:

i) Orders/Contracts below the value of Rs. 50 Lakhs if Vendor/ Supplier/Contractor/ Consultant is not on watch list/ holiday list/ banning list.

ii) Orders for Misc./Administrative items/ Non stock Non valuated items (PO with material code ending with 9).

However, concerned Engineer-in-Charge /OICs will continue to monitor such cases so as to minimize the impact on Projects/O&M plants due to non performance of Vendors/ Suppliers/Contractors/ Consultants in all such cases.
5.0 REVIEW & RESTORATION OF PARTIES PUT ON HOLIDAY

5.1 An order for Holiday passed for a certain specified period shall be deemed to have been automatically revoked on the expiry of that specified period and it will not be necessary to issue a specific formal order of revocation.

Further, in case Vendor/Supplier/Contractor/Consultant is put on holiday due to quality, and new order is placed on bidder after restoration of Vendor/Supplier/Contractor/Consultant, such order will be properly monitored during execution stage by the concerned site.

6.0 EFFECT OF HOLIDAY

6.1 If a Vendor/Supplier/Contractor/Consultant is put on Holiday, such Vendor/Supplier/Contractor/Consultant should not be considered in ongoing tenders/future tenders.

6.2 However, if such Vendor/Supplier/Contractor/Consultant is already executing any other order/contract and their performance is satisfactory in terms of the relevant contract, should be allowed to continue till its completion without any further increase in scope except those incidental to original scope mentioned in the contract. In such a case CPBG will not be forfeited and payment will be made as per provisions of concerned contract. However, this would be without prejudice to other terms and conditions of the contract.

6.3. Effect on other ongoing tendering:

6.3.1 after issue of the enquiry/bid/tender but before opening of Technical bid, the bid submitted by the party shall be ignored.

6.3.2 after opening Technical bid but before opening the Price bid, the Price bid of the party shall not be opened and BG/EMD submitted by the party shall be returned to the party.

6.3.3 after opening of price, BG/EMD made by the party shall be returned; the offer of the party shall be ignored & will not be further evaluated. If errant party emerges as the lowest (L1), then such tender shall also be cancelled and re-invited.

7.0 While putting the Vendor/Supplier/Contractor/Consultant on holiday as per the procedure, the holding company, subsidiary, joint venture, sister concerns, group division of the errant Vendor/Supplier/Contractor/Consultant shall not be considered for putting on holiday list.

Any bidder, put on holiday, will not be allowed to bid through consortium route also in new tender during the period of holiday.

8.0 If an unsuccessful bidder makes any vexatious, frivolous or malicious complaint against the tender process with the intention of delaying or defeating any procurement or causing loss to TFL or any other bidder, such bidder will be put on holiday for a period of six months, if such complaint is proved to be vexatious, frivolous or malicious, after following the due procedure.
9. **APPEAL AGAINST THE DECISION OF THE COMPETENT AUTHORITY:**

(a) The party may file an appeal against the order of the Competent Authority for putting the party on Holiday list. The appeal shall be filed to Appellate Authority. Such an appeal shall be preferred within one month from the receipt of Holiday order.

(b) Appellate Authority would consider the appeal and pass appropriate order which shall be communicated to the party as well as the Competent Authority.

(c) Appeal process may be completed within 45 days of filing of appeal with the Appellate Authority.

(d) “Appellate Authority” shall mean Committee of Directors consisting of Director (Finance) and Director (BD) for works centers under Director (Projects). For all other cases committee of Directors shall consist of Director (Finance) & Director (Projects).

10. **ERRANT BIDDER**

In case after price bid opening the overall lowest evaluated bidder is not awarded the job for any mistake committed by him in bidding or withdrawal of bid or modification of bid or varying any term in regard thereof leading to re-tendering, such bidders shall be debarred from participation in re-tendering of the same job(s)/item(s).

Further, such bidder will be put on holiday for a period of six months after following the due procedure.

11. In case CBIC (Central Board of Indirect Taxes and Customs)/ any tax authority / any equivalent government agency brings to the notice of TFL that the Consultant has not remitted the amount towards GST (CGST & SGST/UTGST or IGST) collected from TFL to the government exchequer, then, that Contactor shall be put under Holiday list of TFL for period of six months after following the due procedure. This action will be in addition to the right of recovery of financial implication arising on TFL.
## TALCHER FERTILIZERS LIMITED
### PERFORMANCE RATING DATA SHEET
**(FOR PROJECTS/ CONSULTANCY JOBS)**

**i)** Project/Work Centre :  

**ii)** Order/ Contract No. & date :  

**iii)** Brief description of Items Works/Assignment :  

**iv)** Order/Contract value (Rs.) :  

**v)** Name of Vendor/Supplier/ Contractor/ Consultant :  

**vi)** Contracted delivery/ Completion Schedule :  

**vii)** Actual delivery/ Completion date :  

<table>
<thead>
<tr>
<th>Performance Parameter</th>
<th>Delivery/ Completion Performance</th>
<th>Quality Performance</th>
<th>Reliability Performance#</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Marks</td>
<td>40</td>
<td>40</td>
<td>20</td>
<td>100</td>
</tr>
</tbody>
</table>

**Marks Allocated**

**Note:**

**Remarks (if any)**

**PERFORMANCE RATING (***)**

**Note:**

(##) Vendor/Supplier/Contractor/Consultant who seek repeated financial assistance or deviation beyond contract payment term or seeking direct payment to the sub-vendor/sub-contractor due to financial constraints, then ‘0’ marks should be allotted against Reliability Performance.

(**) Allocation of marks should be as per enclosed instructions

(*** Performance rating shall be classified as under :

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Range (Marks)</th>
<th>Rating</th>
<th>Signature of Authorised Signatory:</th>
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<tbody>
<tr>
<td>1</td>
<td>60 &amp; below</td>
<td>POOR</td>
<td>Name:</td>
</tr>
<tr>
<td>2</td>
<td>61-75</td>
<td>FAIR</td>
<td>Designation:</td>
</tr>
<tr>
<td>3</td>
<td>76-90</td>
<td>GOOD</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>More than 90</td>
<td>VERY GOOD</td>
<td></td>
</tr>
</tbody>
</table>
Instructions for allocation of marks

1. Marks are to be allocated as under:

1.1 **DELIVERY/ COMPLETION PERFORMANCE** 40 Marks

<table>
<thead>
<tr>
<th>Delivery Period / Completion Schedule</th>
<th>Delay in Weeks</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Upto 3 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
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<td>0</td>
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</tbody>
</table>

1.2 **QUALITY PERFORMANCE** 40 Marks

For Normal Cases: No Defects/ No Deviation/ No failure: 40 marks

- i) Rejection/Defects: Marks to be allocated on prorata basis as compared to total quantity for normal cases 10 marks
  - ii) When quality failure endanger system integration failure - Moderate nature 5 marks
  - - Low severe nature 10-25 marks

- iii) Number of deviations:
  - 1. No deviation 5 marks
  - 2. No. of deviations ≤ 2 2 marks
  - 3. No. of deviations > 2 0 marks
## 1.3 RELIABILITY PERFORMANCE

**20 Marks**

### A. FOR WORKS/CONTRACTS

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
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<tr>
<td>i)</td>
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<td>v)</td>
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### B. FOR SUPPLIES

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<td>5 marks</td>
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<td>iii)</td>
<td>Response to various correspondence and conformance to standards like ISO</td>
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TALCHER FERTILIZERS LIMITED

PERFORMANCE RATING DATA SHEET [PRDS] (FOR O&M)

i) Location:

ii) Order/ Contract No. & date:

iii) Brief description of Items Works/Assignment:

iv) Order/Contract value (Rs.):

v) Name of Vendor/Supplier/ Contractor/ Consultant:

vi) Contracted delivery/ Completion Schedule:

vii) Actual delivery/ Completion date:

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Marks Allocated (*)

Remarks (if any) PERFORMANCE RATING (**)

Note:

(#{}) Vendor/Supplier/Contractor/Consultant who seek repeated financial assistance or deviation beyond contract payment term or seeking direct payment to the sub-vendor/sub-contractor due to financial constraints, then '0' marks should be allotted against Reliability Performance.

(*) Allocation of marks should be as per enclosed instructions.

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1. Marks are to be allocated as under:

1.1 DELIVERY/COMPLETION PERFORMANCE 40 Marks

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i) Rejection/Defects Marks to be allocated on prorata basis for acceptable quantity as compared to total quantity for normal cases 10 marks

ii) When quality failure endanger Failure of severe nature 0 marks

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and safety of the system - low severe nature 10-25 marks

iii) Number of deviations 1. No deviation 5 marks

2. No. of deviations ≤ 2 2 marks

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</table>
ADDENDUM TO INSTRUCTIONS TO BIDDERS
INSTRUCTIONS FOR SUBMISSION OF BID ONLINE THROUGH CPP PORTAL

1. The bidders are required to submit soft copies of their bids electronically on the CPP Portal, using valid Digital Signature Certificates. The instructions given below are meant to assist the bidders in registering on the CPP Portal, prepare their bids in accordance with the requirements and submitting their bids online on the CPP Portal. More information useful for submitting online bids on the CPP Portal may be obtained at: https://etenders.gov.in/eprocure/app.

2. REGISTRATION
   i. Bidders are required to enroll on the e-Procurement module of the Central Public Procurement Portal (URL: https://etenders.gov.in/eprocure/app) by clicking on the link “Online bidder Enrollment” on the CPP Portal which is free of charge.
   ii. As part of the enrollment process, the bidders will be required to choose a unique username and assign a password for their accounts.
   iii. Bidders are advised to register their valid email address and mobile numbers as part of the registration process. These would be used for any communication from the CPP Portal.
   iv. Bidders are advised to make ensure the accessibility & availability of java software in their system (PC) either download & install the latest version of java software or click on the below link to install the java in their system prior to proceed further. https://www.oracle.com/technetwork/java/javase/downloads/index.html
   v. Upon enrollment, the bidders will be required to register their valid Digital Signature Certificate (Class III Certificates with signing key usage) issued by any Certifying Authority recognized by CCA India (e.g. Sify / nCode / eMudhra etc.), with their profile.
   vi. Only one valid DSC should be registered by a bidder. Please note that the bidders are responsible to ensure that they do not lend their DSC’s to others which may lead to misuse.
   vii. Bidder then logs in to the site through the secured log-in by entering their user ID / password and the password of the DSC / e-Token.

3. SEARCHING FOR TENDER DOCUMENTS
   i. There are various search options built in the CPP Portal, to facilitate bidders to search active tenders by several parameters. These parameters could include Tender ID, Organization Name, Location, Date, Value, etc. There is also an option of advanced search for tenders, wherein the bidders may combine a number of search parameters such as Organization Name, Form of Contract, Location, Date, Other keywords etc. to search for a tender published on the CPP Portal.
   ii. Once the bidders have selected the tenders they are interested in, they may download the required documents / tender schedules. These tenders can be moved to the respective ‘My Tenders’ folder. This would enable the CPP
Portal to intimate the bidders through SMS / email in case there is any corrigendum issued to the tender document.

iii. The bidder should make a note of the unique Tender ID assigned to each tender, in case they want to obtain any clarification / help from the Helpdesk.

4. PREPARATION OF BIDS
   i. Bidder should take into account any corrigendum published on the tender document before submitting their bids.
   
   ii. Please go through the tender advertisement and the tender document carefully to understand the documents required to be submitted as part of the bid. Please note the number of covers in which the bid documents have to be submitted, the number of documents - including the names and content of each of the document that need to be submitted. Any deviations from these may lead to rejection of the bid.
   
   iii. Bidder, in advance, should get ready the bid documents to be submitted as indicated in the tender document / schedule and generally, they can be in PDF / XLS / RAR / DWF/JPG formats. Bid documents may be scanned with 100 dpi with black and white option which helps in reducing size of the scanned document.
   
   iv. To avoid the time and effort required in uploading the same set of standard documents which are required to be submitted as a part of every bid, a provision of uploading such standard documents (e.g. PAN card copy, annual reports, auditor certificates etc.) has been provided to the bidders. Bidders can use “My Space” or “Other Important Documents" area available to them to upload such documents. These documents may be directly submitted from the “My Space” area while submitting a bid, and need not be uploaded again and again. This will lead to a reduction in the time required for bid submission process.

Note: My Documents space is only a repository given to the Bidders to ease the uploading process. If Bidder has uploaded his Documents in My Documents space, this does not automatically ensure these Documents being part of Technical Bid.

5. SUBMISSION OF BIDS
   i. Bidder should log into the site well in advance for bid submission so that they can upload the bid in time i.e. on or before the bid submission time. Bidder will be responsible for any delay due to other issues.
   
   ii. The bidder has to digitally sign and upload the required bid documents one by one as indicated in the tender document.
   
   iii. Bidders are requested to note that they should necessarily submit their financial bids in the format provided and no other format is acceptable. If the price bid has been given as a standard SOR format with the tender document, then the same is to be downloaded and to be filled by all the bidders. Bidders are required to download the SOR file, open it and complete the white coloured (unprotected) cells with their respective financial quotes and other details (such as name of the bidder). No other cells should be changed. Once the details have been completed, the bidder should save it
and submit it online, without changing the filename. If the SOR file is found to be modified by the bidder, the bid will be rejected.

iv. The server time (which is displayed on the bidders’ dashboard) will be considered as the standard time for referencing the deadlines for submission of the bids by the bidders, opening of bids etc. The bidders should follow this time during bid submission.

v. All the documents being submitted by the bidders would be encrypted using PKI encryption techniques to ensure the secrecy of the data. The data entered cannot be viewed by unauthorized persons until the time of bid opening. The confidentiality of the bids is maintained using the secured Socket Layer 128 bit encryption technology. Data storage encryption of sensitive fields is done. Any bid document that is uploaded to the server is subjected to symmetric encryption using a system generated symmetric key. Further this key is subjected to asymmetric encryption using buyers/bid opener’s public keys. Overall, the uploaded tender documents become readable only after the tender opening by the authorized bid openers.

vi. The uploaded tender documents become readable only after the tender opening by the authorized bid openers.

vii. Upon the successful and timely submission of bids (i.e. after Clicking “Freeze Bid Submission” in the portal), the portal will give a successful bid submission message & a bid summary will be displayed with the bid no. and the date & time of submission of the bid with all other relevant details.

viii. The bid summary has to be printed and kept as an acknowledgement of the submission of the bid. This acknowledgement may be used as an entry pass for any bid opening meetings.

6. ASSISTANCE TO BIDDERS

i. Any queries relating to the tender document and the terms and conditions contained therein should be addressed to the Tender Inviting Authority for a tender or the relevant contact person indicated in the tender.

ii. Any queries relating to the process of online bid submission or queries relating to CPP Portal in general may be directed to the 24x7 CPP Portal Helpdesk.

iii. Further if at all the issues could not resolved, then bidder may click & follow the link mentioned below for any queries relating to the searching, filling, submission of tender document on CPP portal; https://etenders.gov.in/eprocure/app?page=HelpForContractors&service=page

ANNEXURE-IV

BIDDING DATA SHEET (BDS)

ITB TO BE READ IN CONJUNCTION WITH THE FOLLOWING:

<table>
<thead>
<tr>
<th>ITB clause</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. GENERAL</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>The Invitation for Bid/ Tender is for</td>
</tr>
<tr>
<td>1.1</td>
<td>The Employer/Owner is: Talcher Fertilizers Limited</td>
</tr>
<tr>
<td>2.1</td>
<td>The name of the Works / Services to be performed is: STEAM GENERATION PLANT ON LSTK BASIS</td>
</tr>
<tr>
<td>3</td>
<td>BIDS FROM CONSORTIUM / JOINT VENTURE</td>
</tr>
<tr>
<td></td>
<td>APPLICABLE   X</td>
</tr>
<tr>
<td></td>
<td>NOT APPLICABLE ✓</td>
</tr>
</tbody>
</table>

B. TENDER DOCUMENT

8.1 For clarification purposes only, the communication address is:
M/s Projects & Development India Limited,
P.D.I.L Bhawan, A-14, Sector-1,
Noida, (PIN 201301)
Dist. Gautam Budh Nagar (UP). (India)

Kind Attention:
Mr. P.R.Sahu, Addl. General Manager (M.M)
Fax no. : +91-120-2529801
Tel no. : +91-120-2544063

E-mail : prsahu@pdilin.com
         anjali@pdilin.com
         alam@pdilin.com

C. PREPARATION OF BID

11.1.1 The Bidder shall submit with its Part-I (Techno-commercial/ Unpriced bid) as detailed in 11.1.1 of ITB

12 Additional Provision for Price Schedule/ Schedule of Rate (SOR) / Bid Price are as under:
   1. Guaranteed Work Cost
   2. Monthly Payment Schedule
   3. Daily Hourly Rate
   4. List of Two Years Mandatory Spares
   5. Preamble to SOR

14 The currency of the Bid shall be INR

15 The bid validity period shall be 06(Six) months from final 'Bid Due Date'.

16.1 In case 'Earnest Money / Bid Security' is in the form of 'Demand Draft', the same should be in favor of Talcher Fertilizers Limited, payable at NOIDA
Details of OWNER’s Bank:
State Bank of India
Current Account No. 37088269547
Sector-2, Gautam Budh Nagar,
Noida (U.P.) – 201301
IFS Code: SBIN0005936

**D. SUBMISSION AND OPENING OF BIDS**

<table>
<thead>
<tr>
<th>22.3 and 4.0 of IFB</th>
<th>For submission of physical document as per clause no. 4.0 of IFB, the Owner’s address is:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M/s Projects &amp; Development India Limited, P.D.I.L Bhawan, A-14, Sector-1, Noida, (PIN 201301) Dist. Gautam Budh Nagar (UP). (India)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>26</th>
<th>The bid opening shall take place at:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M/s Projects &amp; Development India Limited, P.D.I.L Bhawan, A-14, Sector-1, Noida, (PIN 201301) Dist. Gautam Budh Nagar (UP). (India)</td>
</tr>
</tbody>
</table>

Date: 25.02.2020
Time: 11.30 hrs IST

**E. EVALUATION, AND COMPARISON OF BIDS**

<table>
<thead>
<tr>
<th>32</th>
<th>Evaluation Methodology is mentioned in Section-II.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>33</th>
<th>Compensation for Extended Stay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>APPLICABLE</td>
</tr>
<tr>
<td></td>
<td>NOT APPLICABLE</td>
</tr>
</tbody>
</table>

**F. AWARD OF CONTRACT**

<table>
<thead>
<tr>
<th>37</th>
<th>State of which stamp paper is required for Contract Agreement: Uttar Pradesh (U.P.) / State where Bidder’s Corporate or Registered Office is located.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>38</th>
<th>Contract Performance Security (CPS)/ Security Deposit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>APPLICABLE</td>
</tr>
<tr>
<td></td>
<td>NOT APPLICABLE</td>
</tr>
</tbody>
</table>

The value/ amount of Contract Performance Security/ Security Deposit SD/CPBG @ 10% of Order/ Contract Value exclusive of GST within 30 days of FOA/ Notification of award.
<table>
<thead>
<tr>
<th>40</th>
<th>Whether tendered item is non-split able or not-divisible:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>NO</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>41</th>
<th>Provision of AHR item:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>APPLICABLE</td>
</tr>
<tr>
<td></td>
<td>NOT APPLICABLE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>49</th>
<th>Quarterly Closure of Contract</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>APPLICABLE</td>
</tr>
<tr>
<td></td>
<td>NOT APPLICABLE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clause no. 31.1.4 of GCC</th>
<th>Bonus for Early Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>APPLICABLE</td>
</tr>
<tr>
<td></td>
<td>NOT APPLICABLE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>50</th>
<th>Applicability of provisions relating to Startups:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>APPLICABLE</td>
</tr>
<tr>
<td></td>
<td>NOT APPLICABLE</td>
</tr>
</tbody>
</table>
## PPP POLICY

Salient Points of Public Procurement (Preference to Make in India) Policy

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description</th>
<th>Parameter / Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minimum Local Content for Availing Preference under this Policy</td>
<td>50%</td>
</tr>
<tr>
<td>2</td>
<td>Margin of Purchase Preference</td>
<td>20%</td>
</tr>
</tbody>
</table>
| 3       | Documents to be submitted by bidder for availing Purchase Preference under this Policy (*) | (a) Self-Certificate from bidder as per Form F-2 in case value is less than Rs. 10 Crores (excluding GST)  
               OR 
               (b) Certificate from the statutory auditor or cost auditor of the company (in case of companies) or from a practicing cost accountant or practicing chartered accountant as per Form F-3 in case value is Rs. 10 Crores (excluding GST) or more than Rs. 10 Crores (excluding GST). |
| 4       | Whether tender is divisible or not divisible (*)                             | (a) Divisible; Clause No. 3 (b) of Policy is applicable                              
               (b) Not Divisible; Clause No. 3 (c) of Policy is applicable                      |
| 5       | Bidder to clearly indicate preference of policy [PPP for MSEs / PP (Preference to Make in India)] for tender related to Supply of Goods & Services. (**) | (a) Public Procurement Policy For MSEs (Micro & Small Enterprises) Order 2012  
               OR 
               (b) Public Procurement (Preference To Make In India) Policy                     |

Note:  
(*) For Sr. No. 3 & 4, strike out whichever is not applicable.  
(**) Sr. No. 5 will not be applicable for “Works Contract”
## FORM-1

### UNDERTAKING FOR APPLICABILITY OF POLICY

To,

M/s Talcher Fertilizers Limited

________________________

SUB: TENDER NO:

Dear Sir,

We, M/s ……………………… (Name of Bidder) hereby confirm that following purchase preference to be considered:-

<table>
<thead>
<tr>
<th>Description</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Procurement (Preference To Make In India) Policy or Purchase Preference under Public Procurement Policy For MSEs (MICRO &amp; SMALL ENTERPRISES) Order 2012</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

i. Please indicate your preference against only one policy.

ii. The above preference shall be extended only after submission of requisite documents (as mentioned in the tender documents).

iii. In case a bidder eligible to seek benefit under Public Procurement (Preference to Make in India) Policy as well as PPP for MSE 2012, than the bidder should categorically seek benefits against only one of the two policies i.e. either Public Procurement (Preference to make in India) Policy or MSE policy.

iv. In case MSEs bidder opts for purchase Preference based on Public Procurement (Preference to Make in India) Policy, he shall not be entitle to claim purchase preference benefit available to MSE Bidders under PPP for MSE 2012. However, the exemptions from furnishing EMD shall continue to be available to MSE Bidders.

v. The option once exercised cannot be modified subsequently.

Place: [Signature of Authorized Signatory of Bidder]

Date: Name:

Designation:

Seal:
FORM-2
DECLARATION BY BIDDER TOWARDS MINIMUM LOCAL CONTENT
(FOR SUPPLY OF GOODS / SERVICES / WORKS / EPC / LSTK)

To,
M/s Talcher Fertilizers Limited

SUB:

TENDER NO:

Dear Sir,

A. We M/s …………………. (Name of Bidder) hereby confirm/certify that the goods / services offered vide our offer no………………. dated ………. meets the mandatory minimum Local content requirement of ……………………..% specified in tender document no. …………………… for claiming purchase preference under Public Procurement (Preference to Make in India) Policy.

B. The details of the location at which the local value addition is made as follows:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Item Description</th>
<th>Details of the Location(s) where the local value addition is made</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Place: [Signature of Authorized Signatory of Bidder]
Date: Name:
     Designation:
     Seal:

Note:

i. This Form is to be submitted by the bidder only if the total quoted price is less than Rs. 10 Crores excluding GST.

ii. The Authorized Signatory of Bidder shall be the person in whose name Power of Attorney has been issued.
FORM – 3

CERTIFICATE FROM STATUTORY AUDITOR OR COST AUDITOR OF THE COMPANY (IN THE CASE OF COMPANIES) OR FROM A PRACTICING COST ACCOUNTANT OR PRACTICING CHARTERED ACCOUNTANT (IN RESPECT OF SUPPLIERS OTHER THAN COMPANIES) TOWARDS MINIMUM LOCAL CONTENT (FOR SUPPLY OF GOODS/ SERVICES / WORKS / EPC / LSTK)

To,
M/s Talcher Fertilizers Limited

SUB:

TENDER NO:

Dear Sir

A. We ……………………………………………. the Statutory Auditor / Cost Auditor / Practicing Cost Accountant / Practicing Chartered Accountant) have verified relevant records of M/s …………………………………. (Name of the bidder) and certify that M/s …………………………………… (Name of the bidder) meet the mandatory minimum Local content requirement of ........% specified in tender document no………………………………… for claiming purchase preference under Public Procurement (Preference to Make in India) Policy.

B. The details of the location at which the local value addition is made as follows:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Item Description</th>
<th>Details of the Location(s) where the local value addition is made</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Name of Audit Firm / Chartered Accountant: [Signature of Authorized Signatory]
Name:
Date:
Designation:
Seal:
Membership No.:

Note:
i. This Form is to be submitted by the bidder only if the total quoted price is Rs. 10 crores (excluding GST) or in excess of Rs. 10 Crores (excluding GST).
FORMS & FORMATS
## LIST OF FORMS & FORMATS

<table>
<thead>
<tr>
<th>Form No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-1</td>
<td>BIDDER’S GENERAL INFORMATION</td>
</tr>
<tr>
<td>F-2</td>
<td>PROFORMA OF &quot;BANK GUARANTEE&quot; FOR &quot;EARNEST MONEY / BID SECURITY&quot;</td>
</tr>
<tr>
<td>F-3</td>
<td>LETTER OF AUTHORITY</td>
</tr>
<tr>
<td>F-4</td>
<td>PROFORMA OF &quot;BANK GUARANTEE&quot; FOR &quot;CONTRACT PERFORMANCE SECURITY / SECURITY DEPOSIT&quot;</td>
</tr>
<tr>
<td>F-5</td>
<td>AGREED TERMS &amp; CONDITIONS</td>
</tr>
<tr>
<td>F-6</td>
<td>ACKNOWLEDGEMENT CUM CONSENT LETTER</td>
</tr>
<tr>
<td>F-7</td>
<td>BIDDER’S EXPERIENCE</td>
</tr>
<tr>
<td>F-8</td>
<td>CHECKLIST</td>
</tr>
<tr>
<td>F-9</td>
<td>FORMAT FOR CERTIFICATE FROM BANK IF BIDDER’S WORKING CAPITAL IS INADEQUATE</td>
</tr>
<tr>
<td>F-10</td>
<td>FORMAT FOR CHARTERED ACCOUNTANT CERTIFICATE FOR FINANCIAL CAPABILITY OF THE BIDDER</td>
</tr>
<tr>
<td>F-11</td>
<td>BIDDER'S QUERIES FOR PRE BID MEETING</td>
</tr>
<tr>
<td>F-12</td>
<td>E-BANKING FORMAT</td>
</tr>
<tr>
<td>F-13</td>
<td>FORMAT FOR POWER OF ATTORNEY</td>
</tr>
<tr>
<td>F-14</td>
<td>PROFORMA FOR CONTRACT AGREEMENT</td>
</tr>
<tr>
<td>F-15</td>
<td>INTEGRITY PACT</td>
</tr>
<tr>
<td>F-16</td>
<td>INDEMNITY BOND</td>
</tr>
<tr>
<td>F-17</td>
<td>PROFORMA OF CONSORTIUM AGREEMENT</td>
</tr>
<tr>
<td>F-18</td>
<td>PROFORMA FOR BANK GUARANTEE FOR ADVANCE PAYMENTS</td>
</tr>
<tr>
<td>F-19</td>
<td>FORMAT OF LETTER OF NO DEVIATIONS</td>
</tr>
<tr>
<td>F-20</td>
<td>FORMAT FOR CONSTRUCTION SUB-CONTRACTORS APPROVAL (To be provided by Successful Bidder)</td>
</tr>
<tr>
<td>F-21</td>
<td>FORMAT FOR FINANCIAL DETAILS OF HOLDING COMPANY</td>
</tr>
<tr>
<td>F-22</td>
<td>DECLARATION REGARDING BANNED/BLACKLISTED/DELISTING AND LIQUIDATION, COURT RECEIVERSHIP</td>
</tr>
<tr>
<td>F-23</td>
<td>FORMAT OF AGREEMENT TO BE EXECUTED BETWEEN BIDDER AND THEIR FOREIGN BASED SUPPORTING COMPANY ON INDIAN STAMP PAPER OF REQUISITE VALUE DULY NOTARIZED.</td>
</tr>
<tr>
<td>F-24</td>
<td>GUARANTEE BY THE FOREIGN BASED SUPPORTING COMPANY/ GUARANTOR</td>
</tr>
<tr>
<td>F-25</td>
<td>CERTIFICATE ISSUED BY COMPANY SECRETARY OF THE GUARANTOR COMPANY</td>
</tr>
<tr>
<td>F-26</td>
<td>PROFORMA OF &quot;BANK GUARANTEE&quot; TOWARDS PERFORMANCE GUARANTEE BY FOREIGN BASED SUPPORTING COMPANY OF THE BIDDING COMPANY</td>
</tr>
</tbody>
</table>
# BIDDER’S GENERAL INFORMATION

To,
M/s TALCHER FERTILIZERS LIMITED,
NOIDA

TENDER NO:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bidder Name:</td>
</tr>
<tr>
<td>2</td>
<td>Status of Firm</td>
</tr>
<tr>
<td></td>
<td>If Others Specify:</td>
</tr>
<tr>
<td></td>
<td>[Enclose relevant certificates / partnership deed/certificate of Registration, as applicable]</td>
</tr>
</tbody>
</table>
| 3 | Name of Proprietor/ Partners/ Directors of the firm/company | 1.  
|   | 2.  
|   | 3.  |
| 4 | Number of Years in Operation |   |
| 5 | Address of Registered Office | City: ____________________________  
|   | District: ____________________________  
|   | State: ____________________________  
|   | PIN/ZIP : ____________________________  |
| 6 | Bidder’s address where order/contract is to be placed | City: ____________________________  
|   | District: ____________________________  
|   | State: ____________________________  
|   | PIN/ZIP : ____________________________  |
| 7 | Office responsible for executing the contract with GST no. (In case supply of works are from multiple locations, addresses and GST no. of all such locations are to be provided) | City:  
|   | District:  
|   | State:  
|   | PIN/ZIP:  
|   | GST No.:  |
| 8 | Telephone Number & Contact Information of address where order is to be placed | (Country Code) (Area Code) (Telephone Number)  
|   | FAX No. : ____________________________  
<p>|   | e-mail ID: ____________________________  |
| 9 | E-mail Address |   |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| **10** | ISO Certification, if any  
(If yes, please furnish details) |   |
| **11** | PAN No | [Enclose copy of relevant document] |
| **12** | GST No.  
(refer sl. no. 7 above) | [Enclose copy of relevant document] |
| **13** | EPF Registration No.  
(Indian Bidder only) | [Enclose copy of relevant document] |
| **14** | ESI code No. | [Enclose copy of relevant document] |
| **15** | Whether Micro or Small Enterprise  
Yes / No  
(If Yes, Bidder to submit requisite documents as specified it ITB: Clause No. 40) |   |
|   | Whether MSE is owned by SC/ST Entrepreneur(s)  
Yes / No  
(If Yes, Bidder to submit requisite documents as specified it ITB: Clause No. 40) |   |
|   | Whether MSE is owned by Women  
Yes / No  
(If Yes, Bidder to submit requisite documents as specified it ITB: Clause No. 40) |   |
| **16** | Type of Entity  
Corporate/ Non-Corporate (As per CGST/SGST/UTGST Act).  
(In case of Non-Corporate Entity, bidder will submit documentary evidence for same). |   |
| **17** | Whether Bidder is Startups or not  
Yes / No  
(If Yes, Bidder to submit requisite documents as specified it ITB: Clause No. 50) |   |
| **21** | In case of Start-up confirm the following:  
(i) Date of its incorporation/ registration  
(ii) Whether turnover for any financial years since incorporation/ registration has exceed Rs.25 Crores. |   |

Place: [Signature of Authorized Signatory of Bidder]  
Date:  
Name:  
Designation:  
Seal:
FORMAT F-2
PROFORMA OF "BANK GUARANTEE"
FOR "EARNEST MONEY / BID SECURITY"
(To be stamped in accordance with the Stamp Act)

Ref.............. Bank Guarantee No..........
Date..................

To,
M/s TALCHER FERTILIZERS LIMITED
NOIDA

SUB:

TENDER NO:

Dear Sir(s),

In accordance with Letter Inviting Tender under your reference No __________________ M/s. __________________ having their Registered / Head Office at _____________ (hereinafter called the Tenderer), wish to participate in the said tender for ______________________________________________________

As an irrevocable Bank Guarantee against Earnest Money for the amount of ______________ is required to be submitted by the Tenderer as a condition precedent for participation in the said tender which amount is liable to be forfeited on the happening of any contingencies mentioned in the Tender Document.

We, the ____________________________________ Bank at _______________________________ having our Head Office __________________________________________________________ (Local Address)

guarantee and undertake to pay immediately on demand without any recourse to the tenderers by Talcher Fertilizers Limited (TFL), the amount ______________ without any reservation, protest, demur and recourse. Any such demand made by TFL, shall be conclusive and binding on us irrespective of any dispute or difference raised by the Tenderer.

This guarantee shall be irrevocable and shall remain valid up to ____________ [this date should be two (02) months beyond the validity of the bid]. If any further extension of this guarantee is required, the same shall be extended to such required period on receiving instructions from M/s. ___________________________________________ whose behalf this guarantee is issued.

In witness whereof the Bank, through its authorized officer, has set its hand and stamp on this ____________ day of ____________ 20__ at ____________.

WITNESS:

(SIGNATURE)       (SIGNATURE)
(NAME)                   (NAME)
Designation with Bank Stamp

(OFFICIAL ADDRESS) Attorney as per
Power of Attorney No. __________
Date: ________________________
INSTRUCTIONS FOR FURNISHING "BID SECURITY / EARNEST MONEY" BY "BANK GUARANTEE"

1. The Bank Guarantee by Bidders will be given on non-judicial stamp paper as per "Stamp Duty" applicable. The non-judicial stamp paper should be in the name of the issuing Bank. In case of foreign Bank, the said Bank's Guarantee to be issued by its correspondent Bank in India on requisite non-judicial stamp paper.

2. The expiry date should be arrived at in accordance with "ITB: Clause-15.1".

3. The Bank Guarantee by bidders will be given from Bank as specified in "ITB".

4. A letter from the issuing Bank of the requisite Bank Guarantee confirming that said Bank Guarantee / all future communication relating to the Bank Guarantee shall be forwarded to the Employer at its address as mentioned at "ITB".

5. Bidders must indicate the full postal address of the Bank along with the Bank's E-mail / Fax / Phone from where the Earnest Money Bond has been issued.

6. If a Bank Guarantee is issued by a commercial Bank, then a letter to Employer confirming its net worth is more than Rs. 1,000,000,000.00 [Rupees One Hundred Crores] or equivalent along with documentary evidence.
LETTER OF AUTHORITY

[Pro forma for Letter of Authority for Attending Subsequent 'Negotiations' / 'Pre-Bid Meetings' /'Un-priced Bid Opening' / 'Price Bid Opening']

Ref: Date:

To,
M/s TALCHER FERTILIZERS LIMITED, NOIDA

SUB: TENDER NO:

Dear Sir,
I/We, _____________________________________ hereby authorize the following representative(s) for attending any 'Negotiations' / 'Meetings [Pre-Bid Meeting]', 'Un-priced Bid Opening', 'Price Bid Opening' and for any subsequent correspondence / communication against the above Bidding Documents:

[1] Name & Designation ____________________ Signature ___________________
Phone/Cell: 
Fax: 
E-mail: ………………………………….. @ ………………………………

[2] Name & Designation ____________________ Signature ___________________
Phone/Cell: 
Fax: 
E-mail: ……………………………………….. @ ………………………………

We confirm that we shall be bound by all commitments made by aforementioned authorised representative(s).

Place: [Signature of Authorized Signatory of Bidder]
Date: Name:
Designation:
Seal:

Note: This "Letter of Authority" should be on the "letterhead" of the Firm / Bidder and should be signed by a person competent and having the 'Power of Attorney' to bind the Bidder. Not more than 'two [02] persons per Bidder' are permitted to attend "Techno-commercial / Un-priced" & "Price Bid" Openings. Bidders authorized representative is required to carry a copy of this authority letter while attending the un-priced and priced bid opening, the same shall be submitted.
PROFORMA OF "BANK GUARANTEE" FOR "CONTRACT PERFORMANCE SECURITY / SECURITY DEPOSIT" (ON NON-JUDICIAL STAMP PAPER OF APPROPRIATE VALUE)

Ref................... Bank Guarantee No..........  
Date..................

To,  
M/s TALCHER FERTILIZERS LIMITED 
NOIDA 

Dear Sir(s),

M/s. ____________________________________________________________________________ (herein after called the “contractor/supplier” which expression shall wherever the context so require include its successors and assignees) have been placed/ awarded the job/work of ___________________________________________ vide PO/LOA/FOA No. __________________________________________________________________________________________ dated ______ for Talcher Fertilizers Limited having registered office at Plot 2/H, Kalpana Area, BJB Nagar, Khordha, Bhubaneswar – 751014 (herein after called the “TFL” which expression shall wherever the context so require include its successors and assignees).

The Contract conditions provide that the SUPPLIER/CONTRACTOR shall pay a sum of Rs. ___________________________________________________________________ (Rupees ____________________________) as full Contract Performance Guarantee in the form therein mentioned. The form of payment of Contract Performance Guarantee includes guarantee executed by Nationalized Bank/Scheduled Commercial Bank, undertaking full responsibility to indemnify TALCHER FERTILIZERS LIMITED, in case of default.

The said M/s. _____________________________________________________________________________ has approached us and at their request and in consideration of the premises we having our office at ____________________________________________________________________________ have agreed to give such guarantee as hereinafter mentioned.

1. We hereby undertake to give the irrevocable & unconditional guarantee to you that if default shall be made by M/s. __________________________________________________________________ in performing any of the terms and conditions of the tender/order/contract or in payment of any money payable to TALCHER FERTILIZERS LIMITED (TFL) we shall on first demand pay without demur, contest, protest and/ or without any recourse to the contractor to TFL in such manner as TFL may direct the said amount of Rupees ___________________________ only or such portion thereof not exceeding the said sum as you may require from time to time.

2. You will have the full liberty without reference to us and without affecting this guarantee, postpone for any time or from time to time the exercise of any of the powers and rights conferred on you under the order/contract with the said M/s. __________________________________________________________________ and to enforce or to forbear from endorsing any powers or rights or by reason of time being given to the said M/s. __________________________________________________________________ and such postponement forbearance would not have the effect of releasing the bank from its obligation under this debt.
3. Your right to recover the said sum of Rs. __________________________ (Rupees ______________________________________) from us in manner aforesaid is absolute & unequivocal and will not be affected or suspended by reason of the fact that any dispute or disputes have been raised by the said M/s. _________________ and/or that any dispute or disputes are pending before any officer, tribunal or court or arbitrator or any other authority/forum and any demand made by you in the bank shall be conclusive and binding. The bank shall not be released of its obligations under these presents by any exercise by you of its liberty with reference to matter aforesaid or any of their or by reason or any other act of omission or commission on your part or any other indulgence shown by you or by any other matter or changed what so ever which under law would, but for this provision, have the effect of releasing the bank.

4. The guarantee herein contained shall not be determined or affected by the liquidation or winding up dissolution or changes of constitution or insolvency of the said supplier/contractor but shall in all respects and for all purposes be binding and operative until payment of all money due to you in respect of such liabilities is paid.

5. This guarantee shall be irrevocable and shall remain valid up to ___________________ (this date should be 90 days after the expiry of defect liability period/ Guarantee period) _______________. The bank undertakes not to revoke this guarantee during its currency without your previous consent and further agrees that the guarantee shall continue to be enforceable until it is discharged by TFL in writing. However, if for any reason, the supplier/contractor is unable to complete the supply/work within the period stipulated in the order/contract and in case of extension of the date of delivery/completion resulting extension of defect liability period/guarantee period of the supplier/contractor fails to perform the supply/work fully, the bank hereby agrees to further extend this guarantee at the instance of the supplier/contractor till such time as may be determined by TFL. If any further extension of this guarantee is required, the same shall be extended to such required period on receiving instruction from M/s. ___________________________(contractor) on whose behalf this guarantee is issued.

6. Bank also agrees that TFL at its option shall be entitled to enforce this Guarantee against the bank (as principal debtor) in the first instant, without proceeding against the supplier/contractor and notwithstanding any security or other guarantee that TFL may have in relation to the supplier's/contractor's liabilities.

7. The amount under the Bank Guarantee is payable forthwith without any delay by Bank upon the written demand raised by TFL. Any dispute arising out of or in relation to the said Bank Guarantee shall be subject to the exclusive jurisdiction of courts at New Delhi.

8. Therefore, we hereby affirm that we are guarantors and responsible to you on behalf of the Supplier/Contractor up to a total amount of __________(amount of guarantees in words and figures) and we undertake to pay you, upon your first written demand declaring the Supplier/Contractor to be in default under the order/contract and without caveat or argument, any sum or sums within the limits of (amounts of guarantee) as aforesaid, without your needing to prove or show grounds or reasons for your demand or the sum specified therein.

9. We have power to issue this guarantee in your favor under Memorandum and Articles of Association and the undersigned has full power to do under the Power of Attorney, dated ___________ granted to him by the Bank.

Yours faithfully,
_______________
INSTRUCTIONS FOR FURNISHING
"CONTRACT PERFORMANCE SECURITY / SECURITY DEPOSIT" BY "BANK GUARANTEE"

1. The Bank Guarantee by successful Bidder(s) will be given on non-judicial stamp paper as per 'stamp duty' applicable. The non-judicial stamp paper should be in name of the issuing bank. In case of foreign bank, the said Bank Guarantee to be issued by its correspondent bank in India on requisite non-judicial stamp paper and place of Bid to be considered as Delhi.

2. The Bank Guarantee by Bidders will be given from bank as specified in Tender.

3. A letter from the issuing bank of the requisite Bank Guarantee confirming that said Bank Guarantee and all future communication relating to the Bank Guarantee shall be forwarded to Employer.

4. If a Bank Guarantee is issued by a commercial bank, then a letter to Employer and copy to Consultant (if applicable) confirming its net worth is more than Rs. 100,00,00,000.00 [Rupees One Hundred Crores] or its equivalent in foreign currency along with documentary evidence.
To,
M/s TALCHER FERTILIZERS LIMITED
NOIDA

SUB: TENDER NO:

This Questionnaire duly filled in, signed & stamped must form part of Bidder’s Bid and should be returned along with Un-priced Bid. Clauses confirmed hereunder need not be repeated in the Bid.

<table>
<thead>
<tr>
<th>Sl.</th>
<th>DESCRIPTION</th>
<th>BIDDER'S CONFIRMATION</th>
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<tbody>
<tr>
<td>1</td>
<td>Bidder's name and address</td>
<td></td>
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<tr>
<td>2</td>
<td>Bidder confirms currency of quoted prices is in Indian Rupees</td>
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<tr>
<td>3</td>
<td>Bidder confirms quoted prices will remain firm and fixed till complete execution of the order.</td>
<td></td>
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</tbody>
</table>
| 4   | Rate of applicable **GST (CGST & SGST/UTGST or IGST)** quoted in Price Schedule / Schedule of Rates (SOR) | **CGST:** ...............%  
**Plus SGST/UTGST:** ...%  
**Total:** .................%  
**Or**  
**IGST:** ...............% |
| 4.1 | Whether in the instant tender services/works are covered in reverse charge rule of GST (CGST & SGST/UTGST or IGST) | **Yes/ No**  
In case of Yes, please specify GST (CGST & SGST/UTGST or IGST) payable by:  
**TFL:** ...............%  
**Bidder:** ...............% |
<p>| 4.2 | Service Accounting Codes (SAC)/ Harmonized System of Nomenclature (HSN) |                         |
| 4.3 | Bidder hereby confirms that the quoted prices are in compliance with the Section 171 of CGST Act/ SGST Act as mentioned as clause no. 13.10 of ITB |                         |
| 5   | Bidder confirms acceptance of relevant Terms of Payment specified in the Bid Document. |                         |
| 6   | Bidder confirms that Contract Performance Security will be furnished as per Bid Document. |                         |
| 7   | Bidder confirms that Contract Performance Security shall be from any Indian scheduled bank or a branch of an International bank situated in India and registered with Reserve bank of India as scheduled foreign bank. However, in case of bank guarantees from banks other than the Nationalised Indian banks, the bank must be a commercial bank having net worth in excess of Rs 100 crores and a declaration to this effect shall be made by such commercial bank either in the Bank Guarantee itself or separately on its letterhead. |                         |
| 8   | Bidder confirms compliance to Completion Schedule as specified |                         |</p>
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<th>Sl.</th>
<th>DESCRIPTION</th>
<th>BIDDER’S CONFIRMATION</th>
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<td></td>
<td>in Bid document. Confirm contract period shall be reckoned from the date of Fax of Acceptance.</td>
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<td>9.</td>
<td>(i) Bidder confirms acceptance of Mutually Agreed Damages for delay in completion schedule specified in Bid document. (ii) In case of delay, the bills shall be submitted after deducting the mutually agreed damages due to delay (refer MAD Clause).</td>
<td></td>
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<tr>
<td>10.</td>
<td>a) Bidder confirms acceptance of all terms and conditions of Bid Document (all sections). b) Bidder confirms that printed terms and conditions of bidder are not applicable.</td>
<td></td>
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<tr>
<td>11.</td>
<td>Bidder confirms that their offer is valid for period specified in BDS from Final/Extended due date of opening of Techno-commercial Bids.</td>
<td></td>
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<tr>
<td>13.</td>
<td>As per requirement of tender, bidder (having status as Pvt. Ltd. or Limited company) must upload bid duly digitally signed on e-portal through class-3B digital signature (DS). In case, class of DS or name of employee or name of employer is not visible in the digitally signed documents, the bid digitally signed as submitted by the person shall be binding on the bidder.</td>
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<td>14.</td>
<td>Bidder confirms that (i) none of Directors (in Board of Director) of bidder is a relative of any Director (in Board of Director) of Owner or (ii) the bidder is not a firm in which any Director (in Board of Director) of Owner or their relative is not a partner.</td>
<td>Confirmed Not confirmed</td>
</tr>
<tr>
<td>15.</td>
<td>All correspondence must be in ENGLISH language only</td>
<td></td>
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<tr>
<td>16.</td>
<td>Bidder confirms the contents of this Tender Document have not been modified or altered by them. In case, it is found that the tender document has been modified / altered by the bidder, the bid submitted by them shall be liable for rejection.</td>
<td></td>
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<tr>
<td>17.</td>
<td>Bidder confirms that all Bank charges associated with Bidder's Bank shall be borne by Bidder.</td>
<td></td>
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<tr>
<td>18.</td>
<td>No Deviation Confirmation: It may be note that any 'deviation / exception' in any form may result in rejection of Bid. Therefore, Bidder confirms that they have not taken any 'exception / deviation' anywhere in the Bid. In case any 'deviation / exception' is mentioned or noticed, Bidder’s Bid may be rejected.</td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>If Bidder becomes a successful Bidder and pursuant to the provisions of the Tender Document, award is given to them against subject Tender Document, the following Confirmation shall be automatically enforceable: &quot;We agree and acknowledge that the Employer is entering into the Contract/Agreement solely on its own behalf and not on behalf of any other person or entity. In particular, it is expressly understood &amp; agreed that the Government of India is not a party to the Contract/Agreement and has no liabilities, obligations or</td>
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<td>DESCRIPTION</td>
<td>BIDDER'S CONFIRMATION</td>
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<td>rights thereunder. It is expressly understood and agreed that the Purchaser is authorized to enter into Contract/Agreement, solely on its own behalf under the applicable laws of India. We expressly agree, acknowledge and understand that the Purchaser is not an agent, representative or delegate of the Government of India. It is further understood and agreed that the Government of India is not and shall not be liable for any acts, omissions, commissions, breaches or other wrongs arising out of the Agreement. Accordingly, we hereby expressly waive, release and forego any and all actions or claims, including cross claims, VIP claims or counter claims against the Government of India arising out of the Agreement and covenants not to sue to Government of India as to any manner, claim, cause of action or things whatsoever arising of or under the Agreement.</td>
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<td>20.</td>
<td>Bidder to ensure all documents as per tender including clause 11 of Section III and all Formats are included in their bid.</td>
<td></td>
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<tr>
<td>21.</td>
<td>Bidder understands that Tender Document is not exhaustive. In case any activity though specifically not covered in description of 'Schedule of Rates' but is required to complete the work as per Scope of Work, Conditions of Contract, or any other part of Bidding document, the quoted rates will deemed to be inclusive of cost incurred for such activities unless otherwise specifically excluded. Bidder confirms to perform for fulfilment of the contract and completeness of the supplies in all respect within the scheduled time frame and quoted price.</td>
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<td>22.</td>
<td>Bidder hereby confirms that they are not on ‘Holiday’ by OWNER or any of the JV partners of OWNER (viz. GAIL, RCF, CIL, FCIL) or Public Sector Project Management Consultant (like PDIL, EIL, Mecon only due to “poor performance” or “corrupt and fraudulent practices”) or banned by Government department/Public Sector on due date of submission of bid. Further, neither bidder nor their allied agency/(ies) (as defined in the Procedure for Action in case of Corrupt/Fraudulent/ Collusive/Coercive Practices) are on banning list of TFL or any of the JV partner of OWNER viz. GAIL, RCF, CIL, FCIL. Bidder also confirms that they are not under any liquidation, court receivership or similar proceedings or ‘bankruptcy’. In case it comes to the notice of TFL/PDIL that the bidder has given wrong declaration in this regard, the same shall be dealt as ‘fraudulent practices’ and action shall be initiated as per the Procedure for action in case of Corrupt/Fraudulent/ Collusive/Coercive Practices. Further, Bidder also confirms that in case there is any change in status of the declaration prior to award of contract, the same will be promptly informed to TFL/PDIL by them.</td>
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<td>23.</td>
<td>Bidder confirms that, in case of contradiction between the confirmations provided in this format and terms &amp; conditions</td>
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<td>DESCRIPTION</td>
<td>BIDDER’S CONFIRMATION</td>
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<td>mentioned elsewhere in the offer, the confirmations given in this format shall prevail.</td>
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Place: [Signature of Authorized Signatory of Bidder]  
Date:  
Name:  
Designation:  
Seal:  
ACKNOWLEDGEMENT CUM CONSENT LETTER

(On receipt of tender document/information regarding the tender, Bidder shall acknowledge the receipt and confirm his intention to bid or reason for non-participation against the enquiry /tender through e-mail to concerned executive in TFL/PDIL issued the tender, by filling up the Format)

To,
M/s TALCHER FERTILIZERS LIMITED
NOIDA

SUB:
TENDER NO:

Dear Sir,

We hereby acknowledge receipt of a complete set of tender documents along with enclosures for subject item/job and/or the information regarding the subject tender.

- We intend to bid as requested for the subject item/job and furnish following details with respect to our quoting office:

  Postal Address with Pin Code : ........................
  Telephone Number : ....................
  Contact Person : ....................
  E-mail Address : ....................
  Mobile No. : ....................
  Date : ....................
  Seal/Stamp : ....................

- We are unable to bid for the reason given below:

  Reasons for non-submission of bid:

  __________________________________________________________
  Agency's Name : ....................
  Signature : ....................
  Name : ....................
  Designation : ....................
  Date : ....................
  Seal/Stamp : ....................
To,

M/s TALCHER FERTILIZERS LIMITED
NOIDA

SUB:
TENDER NO:

F-7
BIDDER’S EXPERIENCE

Place:                                                                 [Signature of Authorized Signatory of Bidder]
Date:                                                                 Name:
                                                                 Designation:
Seal:

Note:
1. The documents (Work Order/DLOA/FOA, Completion certificate, Execution Certificate etc.) which have been referred/ specified/indicated/submitted in above tabulation format and/or along with bid shall be taken into consideration in reply to queries (if any) during evaluation of Bids. Hence, bidder in his own interest should invariably fill-up this format.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Detailed Description of Job</th>
<th>LOA/WO No. and date</th>
<th>Full Postal Address &amp; phone nos. of Client. Name, designation and address of Engineer/Officer-in-Charge</th>
<th>Capacity</th>
<th>Value of Contract/Order (Specify Currency Amount)</th>
<th>Date of Commencement</th>
<th>Scheduled Completion Time (Months)</th>
<th>Date of Actual Completion</th>
<th>Reasons for delay in execution, if any</th>
<th>Details of satisfactory operation from the date of Acceptance</th>
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CHECK LIST

Bidders are requested to duly fill in the checklist. This checklist gives only certain important items to facilitate the bidder to make sure that the necessary data/information as called for in the bid document has been submitted by them along with their offer. This, however, does not relieve the bidder of his responsibilities to make sure that his offer is otherwise complete in all respects.

Please ensure compliance and tick (√) against following points:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>CHECK BOX</th>
<th>REFERENCE PAGE NO. OF THE BID SUBMITTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Digitally Signing (in case of e-bidding)/ Signing and Stamping (in case of manual bidding) on each sheet of offer, original bidding document including SCC, ITB, GCC, SOR drawings, corrigendum (if any)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>Confirm that the following details have been submitted in the Un-priced part of the bid</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>i</td>
<td>Covering Letter, Letter of Submission</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>ii</td>
<td>EMD / Bid Security as per provisions of Tender</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>iii</td>
<td>Digitally Signing / Signing and Stamping of bidding document along with drawings and corrigendum (if any)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>iv</td>
<td>Power of Attorney in the name of person signing the bid.</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>v</td>
<td>Details and documentary proof required against BEC Criteria of Tender Document</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>vi</td>
<td>Confirm submission of documents along with unpriced bid as per tender requirement.</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>Confirm that all format duly filled in are enclosed with the bid duly Digitally Signed / Signed and Stamped by authorised person(s)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td>Confirm that the price part as per Price Schedule has been uploaded.</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>Confirm that annual reports, duly filled in Form F-10 &amp; Form F-9, if applicable are enclosed in the offer for financial assessment</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>Confirm that Undertaking as per Form 2 and statutory auditor certificate as per Form 3 have been submitted (applicable for PP-LC bidder). In case a bidder is quoting on behalf of a manufacturer, in addition to Form -2 and Form-3, the bidder is required to submit Form -4 and Form-5 to be signed by the manufacturer and the statutory auditor of that manufacturer respectively.</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Place: [Signature of Authorized Signatory of Bidder]

Date: 

Name: 

Designation: 
F-9

FORMAT FOR CERTIFICATE FROM BANK
IF BIDDER’S WORKING CAPITAL IS INADEQUATE/NEGATIVE

(To be provided on Bank's letter head)

Date:

To,
M/s. TALCHER FERTILIZERS LIMITED
NOIDA

Dear Sir,

This is to certify that M/s ...................................................... (name of the bidder with address) (hereinafter referred to as Customer) is an existing customer of our Bank.

The Customer has informed that they wish to bid for TFL's RFQ/Tender no. .................................................. dated ...................... for ....................................................(Name of the supply/work/services/consultancy) and as per the terms of the said RFQ/Tender they have to furnish a certificate from their Bank confirming the availability of line of credit.

Accordingly M/s .................................................. (name of the Bank with address) confirms availability of line of credit to M/s .................................................. (name of the bidder) for at least an amount of Rs./USD ________

It is also confirmed that the net worth of the Bank is more than Rs. 100 Crores (or Equivalent USD) and the undersigned is authorized to issue this certificate.

Yours truly

for .................................................. (Name & address of Bank)

(Authorized signatory)
Name of the signatory:  
Designation:  
Stamp  

Page | 87
F-10

FORMAT FOR CHARTERED ACCOUNTANT CERTIFICATE/ CERTIFIED PUBLIC ACCOUNTANT (CPA) FOR FINANCIAL CAPABILITY OF THE BIDDER

We have verified the Audited Financial Statements and other relevant records of M/s……………………………… (Name of the bidder) and certify the following:

A. AUDITED ANNUAL TURNOVER* OF LAST 3 YEARS:

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount (Currency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1:</td>
<td></td>
</tr>
<tr>
<td>Year 2:</td>
<td></td>
</tr>
<tr>
<td>Year 3:</td>
<td></td>
</tr>
</tbody>
</table>

B. NETWORTH* AS PER LAST AUDITED FINANCIAL STATEMENT:

<table>
<thead>
<tr>
<th>Description</th>
<th>Year ______</th>
<th>Amount (Currency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Net Worth</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. WORKING CAPITAL* AS PER LAST AUDITED FINANCIAL STATEMENT:

<table>
<thead>
<tr>
<th>Description</th>
<th>Year ______</th>
<th>Amount (Currency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Current Assets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Current Liabilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Working Capital (Current Assets-Current liabilities)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Refer Instructions

Notes:
(i) It is further certified that the above mentioned applicable figures are matching with the returns filed with Registrar of Companies (ROC) [Applicable only in case of Indian Companies]
(ii) We confirm that above figures after referring instructions at page 2 of 2 of Format F-10.

Name of Audit Firm:     [Signature of Authorized Signatory]
Chartered Accountant/CPA Name:
Date:                  Designation:
                        Seal:
                        Membership No.:
Instructions for Format F-10:

1. The financial year would be the same as one normally followed by the bidder for its Annual Report.

2. The bidder shall provide the audited annual financial statements as required for this Tender document. Failure to do so would result in the Proposal being considered as non-responsive.

3. For the purpose of this Tender document:
   (i) **Annual Turnover** shall be “Sale Value/ Operating Income”
   (ii) **Working Capital** shall be “Current Assets less Current liabilities” and
   (iii) **Net Worth** shall be Paid up share capital plus Free Reserves & Surplus less accumulated losses, deferred expenditure and miscellaneous expenditure not written off, if any.

4. Above figures shall be calculated after considering the qualification, if any, made by the statutory auditor on the audited financial statements of the bidder including quantified financial implication.

5. This certificate is to be submitted on the letter head of Chartered Accountant/CPA.
F-11
BIDDER'S QUERIES FOR PRE BID MEETING

To,

M/s TALCHER FERTILIZERS LIMITED
NOIDA

SUB:

TENDER NO:

<table>
<thead>
<tr>
<th>SI. NO.</th>
<th>REFERENCE OF TENDER DOCUMENT</th>
<th>BIDDER'S QUERY</th>
<th>OWNER'S REPLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC. NO.</td>
<td>Page No.</td>
<td>Clause No.</td>
<td>Subject</td>
</tr>
</tbody>
</table>

NOTE: The Pre-Bid Queries may be sent by e-mail before due date for receipt of Bidder's queries.

SIGNATURE OF BIDDER: __________________________

NAME OF BIDDER: __________________________
E-Banking Mandate Form

1. Vendor/Customer Name:

2. Vendor/Customer Code:

3. Vendor/Customer Address:

4. Vendor/Customer e-mail id:

5. Particulars of bank account
   a) Name of Bank
   b) Name of branch
   c) Branch code:
   d) Address:
   e) Telephone number:
   f) Type of account (current/saving etc.)
   g) Account Number:
   h) RTGS IFSC code of the bank branch
   i) NEFT IFSC code of the bank branch
   j) 9 digit MICR code

I/We hereby authorize Talcher Fertilizers Limited to release any amount due to me/us in the bank account as mentioned above. I/We hereby declare that the particulars given above are correct and complete. If the transaction is delayed or lost because of incomplete or incorrect information, we would not hold the Talcher Fertilizers Limited responsible.

(Signature of vendor/customer)

BANK CERTIFICATE

We certify that --------------------------- has an Account no. ---------------------------- with us and we confirm that the details given above are correct as per our records.

Bank stamp

Date (Signature of authorized officer of bank)
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POWER OF ATTORNEY (POA)
(To be submitted on the Non-Judicial stamp paper)

TENDER NO:

Description of work:

Name of Bidder:___________________________________________________

The undersigned _________________________ (Name of LEGAL PERSON, i.e. CEO/C&MD/Company Secretary/Partners) is lawfully authorized to issue this POA* on behalf of the company M/s __________________________________________ (Name of bidder) whose registered address is ______________________________________________ and does hereby appoint Mr./Ms _________________________________ (name of authorized person signing the bid document) ______________________________ (Designation) of M/s ___________________________________________________ (Name of bidder) whose signature appears below to be the true and lawful attorney/(s) and authorize him/her to sign the bid (both physically & digitally on CPP Portal), conduct negotiation, sign contracts and execute all the necessary matter related thereto, in the name and on behalf of the company in connection with the tender no. ____________________________________________.

The signature of the authorized person/(s) herein constitutes unconditional obligations of M/s ___________________________________________________ (Name of bidder).

This Power of Attorney (POA) shall remain valid and in full force and effect before we withdraw it in writing (by fax, or mail or post). All the documents signed (within the period of validity of the Power of Attorney) by the authorized person herein shall not be invalid because of such withdrawal.

(*)

(I) In case of a single Bidder, the power of Attorney shall be issued as per the constitution of the bidder as below.

a) In case of Proprietorship: By Proprietor
b) In case of Partnership: by all Partners or Managing Partner.
c) In case of Limited Liability Partnership: by any bidder’s employee authorized in terms of Deed of LLP.
d) In case of Public /Limited Company: POA in favour of authorized employee(s) by Board of Directors through Board Resolution or by the designated officer authorized by Board to do so. Such Board Resolution should be duly countersigned by Company Secretary / MD / CMD / CEO.

(II) Deleted

SIGNATURE OF THE LEGAL PERSON

_______________________________________
(Name of person with Company seal)
SIGNATURE OF THE AUTHORIZED PERSON
(FOR SIGNING THE BID)

__________________________
(Signature)

Name of person: _________________________
E-mail id: _________________________
DSC (Digital Signature Certificate) No.: _________________________
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PROFORMA FOR CONTRACT AGREEMENT  
(To be executed on non-judicial stamp paper of appropriate value)

DLOA No. ……………… dated ………..  

TFL’s PAN No. ……………..  

Contract Agreement for the work of ……………….. of TALCHER FERTILIZERS LIMITED made on …………. between (Name and Address)…………………. , hereinafter called the “CONTRACTOR” (which term shall unless excluded by or repugnant to the subject or context include its successors and permitted assignees) of the one part and TALCHER FERTILIZERS LIMITED hereinafter called the “EMPLOYER” (which term shall, unless excluded by or repugnant to the subject or context include its successors and assignees) of the other part.

WHEREAS

A. The EMPLOYER being desirous of having provided and executed certain work mentioned, enumerated or referred to in the Tender Documents including Letter Inviting Tender, General Tender Notice, General Conditions of Contract, Special Conditions of Contract, Specifications, Drawings, Plans, Time Schedule of completion of jobs, Schedule of Rates, Agreed Variations, other documents has called for Tender.

B. The CONTRACTOR has inspected the SITE and surroundings of WORK specified in the Tender Documents and has satisfied himself by careful examination before submitting his tender as to the nature of the surface, strata, soil, sub-soil and ground, the form and nature of site and local conditions, the quantities, nature and magnitude of the work, the availability of labour and materials necessary for the execution of work, the means of access to SITE, the supply of power and water thereto and the accommodation he may require and has made local and independent enquiries and obtained complete information as to the matters and thing referred to, or implied in the tender documents or having any connection therewith and has considered the nature and extent of all probable and possible situations, delays, hindrances or interferences to or with the execution and completion of the work to be carried out under the CONTRACT, and has examined and considered all other matters, conditions and things and probable and possible contingencies, and generally all matters incidental thereto and ancillary thereof affecting the execution and completion of the WORK and which might have influenced him in making his tender.

C. The Tender Documents including the Notice Letter Inviting Tender, General Conditions of Contract, Special Conditions of Contract, Schedule of Rates, General Obligations, SPECIFICATIONS, DRAWINGS, PLANS, Time Schedule for completion of Jobs, Letter of Acceptance of Tender and any statement of agreed variations with its enclosures copies of which are hereto annexed form part of this CONTRACT though separately set out herein and are included in the expression “CONTRACT” wherever herein used.

AND WHEREAS
The EMPLOYER accepted the Tender of the CONTRACTOR for the provision and the execution of the said WORK at the rates stated in the schedule of quantities of the work and finally approved by EMPLOYER (hereinafter called the "Schedule of Rates") upon the terms and subject to the conditions of CONTRACT.

NOW THIS AGREEMENT WITNESSETH AND IT IS HEREBY AGREED AND DECLARED AS FOLLOWS:-

1. In consideration of the payment to be made to the CONTRACTOR for the WORK to be executed by him, the CONTRACTOR hereby covenants with EMPLOYER that the CONTRACTOR shall and will duly provide, execute and complete the said work and shall do and perform all other acts and things in the CONTRACT mentioned or described or which are to be implied there from or may be reasonably necessary for the completion of the said WORK and at the said times and in the manner and subject to the terms and conditions or stipulations mentioned in the contract.

2. In consideration of the due provision execution and completion of the said WORK, EMPLOYER does hereby agree with the CONTRACTOR that the EMPLOYER will pay to the CONTRACTOR the respective amounts for the WORK actually done by him and approved by the EMPLOYER at the Schedule of Rates and such other sum payable to the CONTRACTOR under provision of CONTRACT, such payment to be made at such time in such manner as provided for in the CONTRACT.

A N D

3. In consideration of the due provision, execution and completion of the said WORK the CONTRACTOR does hereby agree to pay such sums as may be due to the EMPLOYER for the services rendered by the EMPLOYER to the CONTRACTOR, such as power supply, water supply and others as set for in the said CONTRACT and such other sums as may become payable to the EMPLOYER towards the controlled items of consumable materials or towards loss, damage to the EMPLOYER'S equipment, materials construction plant and machinery, such payments to be made at such time and in such manner as is provided in the CONTRACT.

It is specifically and distinctly understood and agreed between the EMPLOYER and the CONTRACTOR that the CONTRACTOR shall have no right, title or interest in the SITE made available by the EMPLOYER for execution of the works or in the building, structures or work executed on the said SITE by the CONTRACTOR or in the goods, articles, materials etc., brought on the said SITE (unless the same specifically belongs to the CONTRACTOR) and the CONTRACTOR shall not have or deemed to have any lien whatsoever charge for unpaid bills will not be entitled to assume or retain possession or control of the SITE or structures and the EMPLOYER shall have an absolute and unfettered right to take full possession of SITE and to remove the CONTRACTOR, their servants, agents and materials belonging to the CONTRACTOR and lying on the SITE.

The CONTRACTOR shall be allowed to enter upon the SITE for execution of the WORK only as a licensee simpliciter and shall not have any claim, right, title or interest in the SITE or the structures erected thereon and the EMPLOYER shall be entitled to terminate such license at any time without assigning any reason.
The materials including sand, gravel, stone, loose, earth, rock etc., dug up or excavated from the said SITE shall, unless otherwise expressly agreed under this CONTRACT, exclusively belong to the EMPLOYER and the CONTRACTOR shall have no right to claim over the same and such excavation and materials should be disposed off on account of the EMPLOYER according to the instruction in writing issued from time to time by the ENGINEER-IN-CHARGE.

In Witness whereof the parties have executed these presents in the day and the year first above written.

Signed and Delivered for and on behalf of EMPLOYER

TALCHER FERTILIZERS LIMITED

_______________________________

Date: __________

Place: __________

IN PRESENCE OF TWO WITNESSES

1. ____________________________
2. ____________________________

_______________________________

_______________________________

Signed and Delivered for and on behalf of the CONTRACTOR.

NAME OF CONTRACTOR

_______________________________

Date: __________

Place: __________

1. ____________________________
2. ____________________________
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INTEGRITY PACT
INTEGRITY
PACT
INTEGRITY PACT

INTRODUCTION:

Talcher Fertilizers Limited (TFL) as one of its endeavour to maintain and foster most ethical and corruption free business environment, have decided to adopt the Integrity Pact, a tool developed by the Transparency International, to ensure that all activities and transactions between the Company (TFL) and its Counterparties (Bidders, Contractors, Vendors, Suppliers, Service Providers/Consultants etc.) are handled in a fair and transparent manner, completely free of corruption.

Considering the above, the details mentioned at attached Annexure-1 are applicable as stated in Instruction to Bidders of Tender Document in addition to the existing stipulation regarding Corrupt and Fraudulent Practices.

The attached copy of the Integrity Pact at Annexure- 2 shall be included in the Bid submitted by the bidder (to be executed by the bidder). In case a bidder does not sign the Integrity Pact, his bid shall be liable for rejection.
Bidder is required to sign the Integrity Pact with TFL as per format & terms and conditions enclosed with tender. In case a bidder does not sign the Integrity Pact, his bid shall be liable for rejection.

I COMMITMENTS AND OBLIGATIONS OF THE “COUNTERPARTY”

a) The Counterparty, directly or indirectly (through agent, consultant, advisor, etc.), shall not pay any bribe/ influence or give undue/ unlawful benefit to anyone to gain undue advantage in dealing with TFL.
b) The Counterparty will not engage in collusion of any kind including price fixation etc. with other Counterparts.
c) The counterparty will not pass TFL’s confidential information to any third party unless specifically authorized by TFL in writing.
d) The Counterparties shall promote and observe best ethical practices within their respective organizations.
e) The Counterparty shall inform the Independent External Monitor.
i) If it received any demand, directly or indirectly, for a bribe/ favour or any illegal gratification/ payment / benefit;
ii) If it comes to know of any unethical or illegal payment / benefit;
iii) If it makes any payment to any TFL associate.
f) The Counterparty shall not make any false or misleading allegations against TFL or its associates.

II VIOLATIONS & CONSEQUENCES:

a) If a Counterparty commits a violation of its Commitments and Obligations under the Integrity Pact Programme during bidding process, their entire Earnest Money Deposit/ Bid Security, would be forfeited and in addition, they would be banned from the TFL business in future as per Section 3.
b) In case of violation of the Integrity pact by Counterparty after award of the Contract, TFL shall be entitled to terminate the Contract. Further, TFL would forfeit the security deposits/ Contract Performance Bank Guarantee.
c) In case it is found that the Counterparty has made any frivolous, untrue and misleading allegations against TFL or its associates, TFL reserves its right to initiate criminal proceedings against the violating Counterparty and may also impose exemplary cost for the same.
INDEPENDENT EXTERNAL MONITORS (IEMS)

Presently the panel consisting of the following Independent External Monitors (IEMs) have been appointed by TFL, in terms of Integrity Pact (IP) which forms part of TFL Tenders/Contracts.

i) Shri Anjan Kumar Banerjee (Email ID: anjan.banerjee@gov.in)
ii) Shri Atul Sobti (Email ID: sobtiatul@gmail.com)

This panel is authorised to examine/consider all references made to it under this tender. The bidder(s), in case of any dispute(s)/complaint(s) pertaining to this tender may raise the issue either with the designated tender issuing officer or Nodal Officer (presently Sh. S. Dasgupta, DGM (C&P) – Email: sdasgupta@gmail.co.in) in TFL or directly with the IEMs on the panel or IEM c/o Chief Vigilance Officer, Rashtriya Chemicals and Fertilizers Ltd., Priyadarshini Building, Eastern Express Highway, Sion, Mumbai Maharashtra, 400022.
INTEGRITY PACT

(To be executed on plain paper)

Between Talcher Fertilizers Limited (TFL) (here-in-after referred to as “Principal”).

AND

_________________________ (here-in-after referred to as “The Bidder/Contractor”).

(Principal and the Bidder / Contractor are here-in-after are referred to individually as “Party” or collectively as “Parties”).

PREAMBLE

The Principal intends to award under laid down organizational procedures, contract/s for

The Principal values full compliance with all relevant laws and regulations, and the principles of economic use of resources, and of fairness and transparency in its relations with its Bidder/s and Contractor/s.

In order to achieve these goals, the Principal will appoint Independent External Monitor (s) (in consultation with Central Vigilance Commission) who will monitor the tender process, the execution of the contract etc. for compliance with the principles mentioned above.

Section 1 – Commitments of the Principal

1. The Principal commits itself to take all measures necessary to prevent corruption and to observe the following Principles in this regard:-

   i) No employee of the Principal, either in person or through family members, including relatives, will in connection with the tender for or the execution of a contract, demand or accept a promise for or accept for him/herself or for a third person, any material or immaterial benefit to which he/she is not legally entitled.

   ii) The Principal shall, during the tender process treat all Bidders with equity. The Principal undertakes and ensures that before and during the tender process shall provide and share the same information to all Bidders and will not provide to any Bidder confidential / additional information through which one particular Bidder could take an advantage in relation to the tender process or the contract execution.

   iii) In case, any misconduct on the part of any official (s) is reported by the BIDDER to the PRINCIPAL with full and verifiable facts and the same is prima facie found to be correct by the PRINCIPAL, necessary disciplinary proceedings, or any other action as deemed fit, including criminal proceedings may be initiated by the PRINCIPAL and such person shall be debarred from further dealings related to the contract process. In such a case, while an enquiry is being conducted by the PRINCIPAL the proceedings under the contract would not be stalled.
2. If the Principal obtains information on the conduct of any of its employees which is a criminal offence under the Anti-Corruption Laws of India, or if there be a substantive suspicion in this regard, the Principal will inform its Vigilance Office and in addition can initiate disciplinary actions.

**Section 2 – Commitments and Undertakings by the Bidder/Contractor**

1. The Bidder / Contractor commits and undertakes to take all measures necessary to prevent malpractices & corruption. He commits himself to observe the following principles during his participation in the tender process and during the contract execution till the validity of Integrity Pact:

i) The Bidder / Contractor undertakes not to, directly or through any other person or firm offer, promise or give or influence to any employee of the Principal associated with the tender process or the execution of the contract or to any other person on their behalf any material or immaterial benefit to which he / she is not legally entitled in order to obtain in exchange any advantage of any kind whatsoever during the tender process or during the execution of the contract till the validity of Integrity Pact.

ii) The Bidder / Contractor undertakes not to enter into any undisclosed agreement or understanding, whether formal or informal with other Bidders. This applies in particular to prices, specifications, certifications, subsidiary contracts, submission or non-submission of bids or any other action to restrict competitiveness or to introduce cartelization in the bidding process.

iii) The Bidder / Contractor undertakes not to commit any offence under the relevant Anti-corruption Laws of India. Further, the Bidder / Contractor will not use improperly any information or document provided by the Principal as part of the business relationship regarding plans, technical proposals and business details, including information contained or transmitted electronically for the purposes of competition or personal gain and will not pass the information/document so acquired on to others.

iv) The Bidder / Contractor will, when presenting his bid undertakes to disclose any and all payments made, is committed to or intends to make to agents, brokers or any other intermediaries in connection with the award of the contract.

v) The bidder (s)/ Contractor (s) of foreign origin shall disclose the name and address of the Agents/ representatives in India, if any. Similarly, the bidder (s)/ contractor (s) of Indian Nationality shall furnish the name and address of the foreign principals, if any.

vi) Bidder(s) / Contractor(s) who have signed the Integrity Pact shall not approach the Courts while representing the matter to IEMs and shall wait for their decision in the matter.

2. The Bidder/ Contractor shall not instigate or cause to instigate any third person to commit any of the actions mentioned above.

The Bidder/Contractor commits to refrain from giving any complaint directly or through any other manner without supporting it with full and verifiable facts.
4. The Bidder/Contractor shall not lend to or borrow any money from or enter into any monetary dealing or transactions, directly or indirectly, with any employee of the Principal.

5. In case of any allegation of violation of any provision(s) of this pact or payment of commission, the Principal or its agencies shall be entitled to examine all the documents including the book of accounts of the Bidder and the Bidder shall provide necessary information and documents in English and shall extend all possible help for the purpose of such examination.

6. The Bidder/ Contractor will not collude with other parties interested in the contract to impair the transparency, fairness and progress of the bidding process, bid evaluation, contracting and implementation of contract.

7. The Bidder/ Contractor will not accept any advantage in exchange for any corrupt practice, unfair means and illegal activities.

Section 3 – Disqualification from tender process and exclusion from future contracts

1. If it is found that the Bidder / Contractor or any one employed by it has committed a transgression through a violation of any provisions of Section 2 so as to put his reliability or credibility into question, the Principal shall be entitled to disqualify such Bidder / Contractor from the tender including banning such Bidder / Contractor from entering into any TFL’s future contract/ tender processes for a period as decided by TFL and also to terminate the contract, if already signed, on that ground. Further, the period of banning shall be as per TFL’s decision and the decision of the Principal in this regard will be final and binding on the Bidder/ Contractor.

2. A transgression is considered to have occurred if the Principal after due consideration of the available evidence, concludes that there is a transgression of the provisions of the Pact.

3. The Bidder with its free consent and without any influence agrees and undertakes to respect and uphold the Principal’s absolute rights to resort to and impose such exclusion and further accepts and undertakes not to challenge or question such exclusion on any ground, including the lack of any hearing before the decision to resort to such exclusion is taken. This undertaking is given freely and after obtaining independent legal advice.

4. Principal is entitled to recover all sums paid by Bidder/ contractor to any middleman or agent or broker with a view to securing the contract.

In cases where irrevocable Letters of credit has to be established in respect of any contract signed by the Principal with the Bidder, the same shall not be opened.

Principal is entitled to forfeit the Performance Bond clearly assigning reason in case Bidder/ Contractor violates this Pact.

Section 4 – Forfeiture of EMD / Security Deposits

1. If due to transgression as per the provisions of the Pact, the Principal has disqualified the Bidder from the tender process prior to the award in terms of Section 3, the Principal is entitled to forfeit earnest money deposit / bid security money. In addition to this, such Bidder/Contractor shall also be
banned from the future business with Principal with consequential actions as decided by TFL.

**Section 5 – Previous transgression**

1. The Bidder declares that no previous transgression has occurred during the last three years immediately before signing of this Integrity Pact, with any other Company in any country in respect of any corrupt practices envisaged hereunder or with any other Public Sector Enterprise / Undertaking or any Government Department in India that could justify Bidder's exclusion from the tender process.

2. If the Bidder makes incorrect statement on this subject, he shall be disqualified from the tender process or the contract, if already awarded, could be liable to be terminated on this ground and other actions can be taken by TFL.

In case of any transgression in the last three years from the date of signing of Integrity Pact, Bidder to provide the details of same in their bid.

**Section 6 – Equal treatment to all Bidders / Contractors / Subcontractors**

1. The Bidder / Contractor undertakes to demand from all its sub-contractors, if any, an undertaking and commitment in conformity with this Integrity Pact, and to submit it to the Principal before signing of the contract.

In case of Sub-Contracting, the Principal Contractor shall take the responsibility of the adoption of Integrity Pact by the Sub-contractor.

2. The Principal will enter into agreements with similar conditions, as stipulated herein, with all Bidders, Contractors and Subcontractors.

3. The Principal shall disqualify from the tender process all Bidders who do not sign this Pact or violate any of its provisions.

**Section 7 – Criminal charges against violating Bidders / Contractors / Sub-contractors**

If the Principal obtains knowledge of conduct of a Bidder, Contractor or Subcontractor, or of an employee or a representative or an associate of a Bidder, Contractor or Subcontractor which constitutes corruption of an offence as defined in Chapter IX of the Indian Penal Code 1860 or prevention of corruption Act 1988 and amendments thereof or any other enacted statute for prevention of corruption, or if the Principal has substantive suspicion in this regard, the Principal will inform the same to the Vigilance Office / Department for initiating appropriate action for above.

**Section 8 – Independent External Monitor / Monitors**

1. The Principal appoints competent and credible external independent Monitor for this Pact. The task of the Monitor is to review independently and objectively, whether and to what extent the parties comply with the obligations under this agreement.

2. The Monitor is not subject to any instructions by the representatives of the parties and performs his functions neutrally and independently. He reports to the Chairperson of the Board of the Principal.
3. The Bidder/Contractor accepts that the Monitor has the right to access without restriction to all Project documentation of the Principal including that provided by the Contractor. The Contractor will also grant the Monitor, upon his request and demonstration of a valid interest, unrestricted and unconditional access to his project documentation. The same is applicable to Sub-contractors. The Monitor is under contractual obligation to treat the information and documents of the Bidder / Contractor / Sub-contractor with confidentiality.

4. The Principal will provide to the Monitor sufficient information about all meetings among the parties related to the Project provided such meetings could have an impact on the contractual relations between the Principal and the Contractor. The parties offer to the Monitor the option to participate in such meetings.

5. As soon as the Monitor notices, or believes to notice, a violation of this Pact he will so inform the Management of the Principal and request the Management to discontinue or heal the violation or to take other relevant action. The monitor can in this regard submit non-binding recommendations. Beyond this, the Monitor has no right to demand from the parties that they act in a specific manner, refrain from action or tolerate action. However, the Independent External Monitor shall give an opportunity to the bidder / contractor to present its case before making its recommendations to the Principal.

6. The Monitor will submit a written report to the Chairperson of the Board of the Principal within 10 days from the date of reference or intimation to him by the ‘Principal’ and should the occasion arise, submit proposals for taking corrective measures.

7. Remuneration payable to Monitor(s) shall be borne by Principal.

8. If the Monitor has reported to the Chairperson of the Board a substantiated suspicion of an offence under relevant Anti-Corruption laws of India, and the Chairperson has not, within reasonable time, taken visible action to proceed against such offence or reported it to the Vigilance Office, the Monitor may also transmit this information directly to the Central Vigilance Commissioner, Government of India.

9. The word ‘Monitor’ would include both singular and plural.

10. Independent External Monitor shall be required to maintain confidentiality of the information acquired and gathered during their tenure / role as Independent Monitor. Any breach in this regard would be subject to the legal judicial system of India.

11. The Independent External Monitors shall be responsible to oversee the implementation of Integrity Pact Program to prevent corruption, bribes or any other unethical practices in the TFL.

12. The monitor has also signed declarations on ‘Non-Disclosure of Confidential Information’ and of ‘Absence of Conflict of Interest’. In case of any conflict of interest arising at a later date, the IEM shall inform Chairperson of the Principal and recuse himself / herself from that case.

In case of any complaints referred under IP Program, the role of IEMs is advisory and would not be legally binding and it is restricted to resolving the
issues raised by an intending bidder regarding any aspect of the tender which allegedly restricts competition on bias towards some bidder.

14. Issues like warranty / guarantee, etc. shall be outside the purview of IEMs.

Section 9 – Pact Duration

The provisions of this Pact shall come into effect from the date of signing of this Pact by the both parties. It expires for the Contractor 12 months after the last payment under the respective contract, and for all other Bidders 6 months after the contract has been awarded.

If any claim is made / lodged by either party during this time, the same shall be binding and continue to be valid despite the lapse of this pact as specified above, unless it is discharged/determined by the Chairperson of the Principal.

Section 10 – Miscellaneous provisions

1. This agreement is subject to Indian Law. Place of performance and exclusive jurisdiction is the Registered Office of the Principal, i.e. New Delhi. The Arbitration clause provided in main tender document / contract shall not be applicable for any issue / dispute arising under Integrity Pact.

2. Changes and supplements as well as termination notices, if any, need to be made in writing. Side agreements have not been made.

3. If the Contractor / Bidder is a partnership concern or a consortium, this agreement must be signed by all partners or consortium members.

4. In case any or several of the provisions of this agreement turn out to be void, the remainder of this pact shall remain valid. The parties to this pact however, shall strive to come to an agreement to their original intentions in such a case.

5. The actions stipulated in this Integrity Pact are without prejudice to any other legal action that may follow in accordance with the provision of the extant law in force relating to any civil or criminal proceeding.

(Name & Designation)  (Name & Designation)  
For the Principal  For the Bidder

Place  Witness 1:  
-----------------  -----------
Date  Witness 2:  
-----------------  -----------
WHEREAS TALCHER FERTILIZERS LIMITED (hereinafter referred to as “TFL”) which expression shall, unless repugnant to the context include its successors and assigns, having its registered office at Plot 2/H, Kalpana Area, BJB Nagar, Khorda, Bhubaneswar – 751014 has entered into a contract with M/s*…………………………. (hereinafter referred to as the “Contractor”) which expression shall unless repugnant to the context include its representatives, successors and assigns, having its registered office at *………………………… and on the terms and conditions as set out, inter-alia in the ................. [mention the work order/LOA/Tender No.] and various documents forming part thereof, hereinafter collectively referred to as the ‘CONTRACT’ which expression shall include all amendments, modifications and / or variations thereto.

TFL has also advised the Contractor to execute an Indemnity Bond in general in favour of TFL indemnifying TFL and its employees and Directors including Independent Directors from all consequences which may arise out of any prospective litigation or proceedings filed or may be initiated by any third party, including any Banker / financial institution / worker(s) /vendor(s)/ subcontractor(s) etc. who may have been associated or engaged by the Contractor directly or indirectly with or without consent of TFL for above works.

NOW, THEREFORE, in consideration of the promises aforesaid, the Contractor hereby irrevocably and unconditionally undertakes to indemnify and keep indemnified TFL and all its employees, Directors, including Independent Directors, from and against all/any claim(s), damages, loss, which may arise out of any litigations/ liabilities that may be raised by the Contractor or any third party against TFL under or in relation to this contract. The Contractor undertakes to compensate and pay to TFL and/or any of its employees, Directors including Independent Directors, forth with on demand without any protest the amount claimed by TFL for itself and for and on behalf of its employees, Directors including Independent Directors together with direct/indirect expenses including all legal expenses incurred by them or any of them on account of such litigation or proceedings.

AND THE CONTRACTOR hereby further agrees with TFL that:

(i) This Indemnity shall remain valid and irrevocable for all claims of TFL and/or any of its employees and Directors including Independent Directors arising out of said contract with respect to any such litigation / court case for which TFL and/or its employees and Directors including Independent Directors has been made party until now or here-in-after.

(ii) This Indemnity shall not be discharged/ revoked by any change/ modification/ amendment/ assignment of the contract or any merger of the Contractor with other entity or any change in the constitution/structure of the Contractor’s firm/ Company or any conditions thereof including insolvency etc. of the Contractor, but shall be in all respects and for all purposes binding and operative until any/ all claims for payment of TFL are settled by the Contractor and/or TFL discharges the Contractor in writing from this Indemnity.

The undersigned has full power to execute this Indemnity Bond for and on behalf of the Contractor and the same stands valid.

SIGNED BY :

For [ Contractor]

Authorised Representative
Place:
Dated:

Witnesses:
1.
2.
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PROFORMA OF CONSORTIUM AGREEMENT

DELETED
Ref................
Bank Guarantee No.-------- Date................

To,
M/s Talcher Fertilizers Limited

Dear Sir(s),

In consideration of the Talcher Fertilizers Limited, hereinafter called the "Owner" which expression shall unless repugnant to the context or meaning thereof include its successors, executors, administrators and assignees, having awarded to M/s........................ having its registered office at ................................... hereinafter referred as the 'CONTRACTOR', which expression shall unless repugnant to the context or meaning thereof, include its successors, administrators, executors and assignees, a contract hereinafter referred to as the 'Contract' for related works.............. referred to as the 'WORK' on terms and conditions set out, inter-alia in the Owner's Contract / DLOA / FOA No..........dated.......... valued at........................................ (in words & figures) and as the Owner having agreed to make an advance payment (herein after referred as Mobilization advance) for the performance of the above contract to the CONTRACTOR amounting to.............................(in words & figures) as an advance against Bank Guarantee to be furnished by the CONTRACTOR.

We........................................... hereinafter referred to as the BANK which expression shall, unless repugnant to the context or meaning thereof, include its successors, administrators, executors and assignees having our office at......................... do hereby undertake to give the irrevocable and unconditional guarantee and do hereby undertake to pay the OWNER on first demand without any demur, reservation, contest, recourse, protest and without reference to the CONTRACTOR any and all monies payable by the CONTRACTOR by reason of any breach by the said CONTRACTOR of any of the terms and conditions of the said Contract to the extent of.............. till the said advance is adjusted as aforesaid at any time upto......................... We agree that the guarantee herein contained shall continue to be enforceable till the sum due to the Owner on account of the said advance is adjusted/recovered in full as aforesaid or till the Owner discharges this guarantee in writing.

The OWNER shall have the fullest liberty without affecting in any way the liability of the BANK under this guarantee, from time to time to vary the advance or to extend the time for performance of the works by the CONTRACTOR. The BANK shall not
be released from its liability under these presents by any exercise of the Owner of the liberty with reference to the matter aforesaid.

The Owner shall have the fullest liberty, without reference to CONTRACTOR and without affecting this guarantee to postpone for any time or from time to time the exercise of any powers vested in them or of any right which they might have against the CONTRACTOR, and to exercise the same at any time in any manner, and either to enforce or to forebear to enforce any power, covenants contained or implied in the Contract between the OWNER and the CONTRACTOR or any other course or remedy or security available to the OWNER and the BANK shall not be released of its obligations under these presents by any exercise by the OWNER of its liberty with reference to matters aforesaid or other acts of omission or commission on the part of the OWNER or any other law would, but for this provision, have the effect of releasing the BANK.

The right of the OWNER to recover the outstanding sum of advance upto Rs.______________ from the BANK in the manner aforesaid is absolute and unequivocal and will not be affected or suspended by reason of the fact that any dispute or disputes has or have been raised by the CONTRACTOR and/or that any dispute or disputes is or are pending before any officer, tribunal or court or arbitrator or any other authority/forum and any demand made by OWNER on the BANK shall be conclusive and binding.

The BANK further undertakes not to revoke this guarantee during its currency without previous consent of the OWNER and further agrees that the guarantee contained shall continue to be enforceable until it is discharged by TFL in writing.

The BANK also agrees that the OWNER shall at its option be entitled to enforce this guarantee against the BANK as a principal debtor, in the first instance, notwithstanding any other security or guarantee that OWNER may have in relation to the CONTRACTOR's liabilities towards the said advance.

The amount under the Bank Guarantee is payable forthwith without any delay by Bank upon the written demand raised by TFL. Any dispute arising out of or in relation to the said Bank Guarantee shall be subject to the exclusive jurisdiction of courts at New Delhi.

Therefore, we hereby affirm that we are guarantors and responsible to you on behalf of the Contractor up to a total amount of ______________(amount of guarantees in words and figures) and we undertake to pay you, upon your first written demand declaring the Contractor to be in default under the contract and without caveat or argument, any sum or sums within the limits of ____________(amount of guarantee) as aforesaid, without your needing to prove or show grounds or reasons for your demand or the sum specified therein.

Notwithstanding anything contained hereinabove, our liability under this guarantee is restricted to _________ and it will remain in force upto and including ______________.
and shall be extended from time to time for such periods as may be advised by M/s_______ on whose behalf this guarantee has been given.

We have power to issue this guarantee in your favour under Memorandum and Articles of Association and the undersigned has full power to do so under the Power of Attorney/ resolution of the Board of Directors dated............... accorded to him by the BANK.

Dated................this............day of............20 ..............

Signed by

(Person duly authorised by Bank)

Place:

WITNESS :
1...................................... (Signature)
...................................... (Printed Name)
...................................... (Designation)

2...................................... (Signature)
...................................... (Printed Name)
...................................... (Designation)

(Common Seal)
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FORMAT OF LETTER OF NO DEVIATIONS
(ON BIDDER’S LETTERHEAD)

(NIT NO : PNMM/PC150/E-4003/NCB DATED ……)

We * hereby agree to fully comply with, abide by and accept without variation, deviation or reservation all technical, commercial and other condition whatsoever of the Bidding Documents and all Addenda / Corrigenda / Clarifications issued by OWNER.

We further hereby confirm that the bid is submitted in accordance of Tender Document and contains no deviation and the price bid submitted may be treated to conform to, in all respects, with the terms and conditions of the said tender documents including all Addenda / Corrigenda/Clarifications.

For and on behalf of*: ..................................................
Stamp & Signature**: ..................................................
Name : ..................................................
Designation : ..................................................
Date : ..................................................

* Here fill in the name of bidder.

** The Letter of No Deviation must be signed by the person (s) authorized to sign.
## FORMAT FOR CONSTRUCTION SUB-CONTRACTORS APPROVAL

### (APPROVAL OF CONSTRUCTION SUB-CONTRACTOR)

<table>
<thead>
<tr>
<th></th>
<th>NAME OF MAIN CONTRACTOR</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2)</td>
<td>NAME OF WORK, LOCATION</td>
<td></td>
</tr>
<tr>
<td>3)</td>
<td>NAME OF PROPOSED SUB-CONTRACTOR</td>
<td></td>
</tr>
<tr>
<td>4)</td>
<td>SCOPE OF WORK PROPOSED TO BE SUB-CONTRACTED (BRIEF)</td>
<td></td>
</tr>
<tr>
<td>5)</td>
<td>ESTIMATED VALUE OF THE PROPOSED WORK TO BE SUB-CONTRACTED (INR)</td>
<td></td>
</tr>
</tbody>
</table>

### QUALIFYING CRITERIA FOR SUB-CONTRACTOR

1. Similar Work experience in Steam Generation and Captive Power Plant:
   - 1 Contract of 60% of estimated value of proposed work to be sub-contracted.

2. Annual Turnover:
   - Not less than 125% of estimated value of proposed work to be sub-contracted

### EXPERIENCE AND FINANACIAL DETAILS OF PROPOSED SUB-CONTRACTOR:

1. Contract Value of similar work executed (as evidenced by work Order & Completion Certificate) During the last 7 years.

2. Maximum Annual Turnover during last 3 (three) years (as evidenced by Balance Sheets)

3. Concurrent Commitments (including the works proposed to be sub-contracted)

### CRITERIA FOR QUALIFICATION OF SUB-CONTRACTOR

1. Sl.No. 7(i) > 6 (i) YES / NO
2. Sl.No. 7(ii) > 6 (ii) YES / NO
<table>
<thead>
<tr>
<th>Sl.No. 7(iii) &gt; 2 x Sl.no.7(ii)</th>
<th>YES / NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>9)</td>
<td>Based on above information, we M/s.__________________ (Name of Main Contractor) propose M/s.__________________ for mentioned works. We understand that notwithstanding above approval, we shall remain fully responsible for the performance of the said sub-contractor and any failure of the sub-contractor shall not absolve/relieve us of our responsibility to complete the work as per the terms and conditions of the Contract.</td>
</tr>
</tbody>
</table>

NOTE : Bidders to fill all the details in the above proforma. Further, Bidder shall also fill-in the details at Sl.No.5 above based on the estimated value of the proposed work to be sub-contracted.

10) QUALIFICATION STATUS (TO BE STAMPED BY OWNER):

For and on behalf of: ...........................................

Stamp & Signature: ...........................................

Name: ............................................................

Designation: ...................................................

Date: ............................................................
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Format for Financial Details of Holding Company

DELETED
To,

M/s Talcher Fertilizers Limited,

SUB:

TENDER

NO:

Dear Sir,

We hereby confirm that we have not been banned or blacklisted or de-listed or put on Holiday by any Government / Quasi-Government / Public Sector Undertaking on due date of submission of bid.

We also confirm that we are not under any liquidation, court receivership or similar proceedings or 'bankruptcy'.

If it is found at a later date that the Contractor has secured the contract by furnishing wrong information or by suppressing facts in the bid submitted, Talcher Fertilizers Limited (TFL) reserves the right to cancel the contract and forfeit the EMD/ Security cum Performance Guarantee and put the CONTRACOR on Holiday / Banned / Blacklist list of TFL and of it’s JV partners.

Further, we also confirm that in case there is any change in status of the declaration prior to award of contract, the same will be promptly informed to TFL by us.

Place: [Signature of Authorized Signatory of Bidder] Date: Name: Designatio n: Seal:
This agreement made this ___ day of ____ month ____ year by and between M/s. ______________ (Fill in Bidder’s full name, constitution and registered office address) ___________ hereinafter referred to as bidder on the first part and M/s. ______________ (Fill in full name, constitution and registered office address company which hold more than fifty percent of the paid up share capital of the bidding company or vice versa) hereinafter referred to as “Supporting Company” of the second part.

Whereas

M/s. Talcher Fertilizers Limited (hereinafter referred to as TFL) has invited offers vide their tender No. _____________ for _______________ and M/s. ________________ (Bidder) intends to bid against the said tender and desires to have technical support of M/s. ________________ [Supporting Company]

And whereas Supporting Company represents that they have gone through and understood the requirements of the subject tender and are capable and committed to provide the services as required by the bidder for successful execution of the contract, if awarded to the bidder.

Now, it is hereby agreed to by and between the parties as follows:

a) M/s. ____________ (Bidder) will submit an offer to TFL for the full scope of work as envisaged in the tender document as a main bidder and liaise TFL directly for any clarifications etc. in this context.

b) M/s. ________ [Supporting Company] undertakes to provide technical support and expertise, expert manpower and project management including financial support, if so required, to the bidder to discharge its obligations as per the Scope of Work of the tender / Contract for which offer has been made by the bidder and accepted the TFL.

c) The Bidder/ Supporting Company holds more than 50% paid up equity capital of the Supporting Company/ Bidder.
d) This agreement will remain valid till validity of bidder’s offer to TFL including extension if any and till satisfactory performance of the contract, the same is awarded by TFL to the bidder.

e) Supporting Company undertakes that this agreement shall remain enforceable even if their stake in Bidder is diminished during the execution of works under the contract between the Bidder and TFL.

f) The bidder shall have the overall responsibility of satisfactory execution of the contract awarded by TFL, however without prejudice to any rights that TFL might have against the Supporting Company

g) It is further agreed that, if contract pursuant to Supporting Company shall be jointly and severely responsible to TFL for the performance of works during contract period and for the satisfactory execution of the contract, and for all the consequences for non-performance thereof.

In witness whereof the parties hereto have executed this agreement on the date mentioned above.

For and on behalf of For and on behalf of
(Bidder) (Supporting Company)
M/s. M/s.

Witness: Witness:
1) 1)
2) 2)
GUARANTEE BY THE FOREIGN BASED SUPPORTING COMPANY/ GUARANTOR

THIS DEED OF GUARANTEE executed at ........... this ........ day of ........ by M/s ........................................ (mention complete name) a company duly established and existing under the laws of ...................... (insert country), having its Registered Office at .......................................................... hereinafter called “the Guarantor and/ or the Supporting Company” which expression shall, unless excluded by or repugnant to the subject or context thereof, be deemed to include its successors and permitted assignees.

FOR

M/s ........................................ (bidder) a company duly established and existing under the laws of ...................... (insert country), having its Registered Office at .......................................................... hereinafter called the “Bidder” which expression shall, unless excluded by or repugnant to the subject or context thereof, be deemed to include its successors and permitted assignees.

TOWARDS

M/s Talcher Fertilizers Limited, a company duly registered under the law of India having its Registered Office at Plot 2/H, Kalpana Area, BJB Nagar, Khurda, Bhubneshwar-751014, Odisha, India, and having Purchase center at .................... hereinafter called “TFL” which expression shall unless excluded by or repugnant to the context thereof, be deemed to include its successor and assignees.

WHEREAS TFL has invited tender number ....................... for ........ on ............... , and the bidder has submitted it bid number ..................... in response to the above mentioned tender invited by TFL.

AND WHEREAS the bidder/ Guarantor Company holds more than 50% paid up equity capital of the Supporting Company/ Bidder .

AND WHEREAS one of the condition for acceptance of Bidder’s bid against said tender is that in case the bidder is seeking to qualify upon the technical credentials of its Guarantor Company, then the bidder shall arrange a guarantee from its Guarantor Company guaranteeing due and satisfactory performance of the work covered under the said tender including any change therein as may be deemed appropriate by the TFL at any stage.

The Guarantor represents that they have gone through and understood the requirement of the above said tender and are capable of and committed to provide technical and such other supports as may be required by the Bidder for successful execution of the same.

The Bidder and the Guarantor have entered into an agreement dated ........ as per which the Guarantor shall be providing technical, financial and such other supports as may be
necessary for performance of the work under the tender, if the contract is awarded to the Bidder.

Accordingly, at the request of the Bidder and in consideration of and as a requirement for the TFL to enter into agreement(s) with the Bidder, the Guarantor hereby guarantees and undertakes that upon award of Contract to Bidder against bid number .............., made by the Bidder under tender number................:

1. The Guarantor unconditionally agrees that in case of non-performance by the Bidder of any of its obligations in any respect, the Guarantor shall, immediately on receipt of notice of demand by the TFL, take up the job without any demur or objection, in continuation and without loss of time and without any cost to the TFL and duly perform the obligations of the Bidder to the satisfaction of the TFL.

2. The Guarantor agrees that the Guarantee contained herein shall remain valid till the satisfactory execution and completion of the work (including discharge of the warranty obligations) awarded to the Bidder.

3. The Guarantor shall be jointly and severally responsible to TFL for satisfactory performance of works during contract period and for the satisfactory execution of the contract, and for all consequences for non-performance thereof.

4. The liability of the Guarantor, under the Guarantee, is limited of the Bidder for non-performance under the contract entered between TFL and the Bidder. This will, however, be in addition to the forfeiture of the Performance and Advance Guarantees furnished by the Bidder.

5. The Guarantor agrees to execute a Corporate Guarantee in favour of TFL, guaranteeing the performance of obligations by the Bidder, in case the Contract is awarded to the Bidder by TFL.

6. The Guarantor represents that this Guarantee has been issued after due observance of the appropriate laws in force in India. The Guarantor hereby undertakes that the Guarantor shall obtain and maintain in full force and effect all the governmental and other approvals and consents that are necessary and do all other acts and things necessary or desirable in connection therewith or for the due performance of the Guarantor's obligations towards TFL.

7. Any dispute arising out of or in connection with this contract, including any question regarding its existence, validity or termination, shall be referred to and finally resolved by arbitration. It is further agreed that Claims by and against the Guarantor, the Bidder and TFL under the different contract to be entered pursuant to their relationship can be brought under a single reference and there shall be no bar on the consolidation of such proceedings before the same arbitral tribunal. The governing law shall be the laws of India and seat of arbitration shall be New Delhi, India. The language of arbitration shall be English.
8. The Guarantor hereby declares and represents that this Guarantee has been given without any undue influence or coercion, and that the Guarantor has fully understood the implications of the same.

9. In case of award of contract to the bidder, the Guarantor shall provide Performance Bank Security to TFL, equivalent to 50% of the value of Performance Bank Security to be submitted by the bidding company, in the prescribed format within 15 days from the date of Fax of Acceptance, as guarantee for performance by the bidder/contractor. The Guarantor hereby expressly agrees that if in the opinion of TFL, the Bidder / Contractor has failed to perform its obligations under the contract in any manner, TFL shall have unfettered right to invoke the said Bank guarantee. The guarantor hereby agrees that decision of TFL about performance of the bidder / contractor shall be final and shall not be questioned by the Guarantor. Guarantor shall have no objection to invocation of the Performance Bank Guarantee submitted by the Guarantor

OR

(applicable, subject to meeting the conditions stipulated in BEC in respect of additional Performance Bank Security)

In case of award of contract to the bidder, the bidder on behalf of the Guarantor shall provide additional Performance Bank Security to TFL, equivalent to 50% of the value of Performance Bank Security to be submitted by the bidding company, in the prescribed format within 15 days from the date of Fax of Acceptance, as guarantee for performance by the bidder/contractor. The Guarantor hereby expressly agrees that if in the opinion of TFL, the Bidder / Contractor has failed to perform its obligations under the contract in any manner, TFL shall have unfettered right to invoke the said Bank guarantee. The Guarantor hereby agrees that decision of TFL about performance of the bidder / contractor shall be final and shall not be questioned by the Guarantor. Guarantor shall have no objection to invocation of the Performance Bank Security submitted by the Guarantor. The Guarantor represents and confirms that the Guarantor has the legal capacity, power and authority to issue this Guarantee and that giving of this Guarantee and the performance and observations of the obligations hereunder do not contravene any existing laws.

(Strike through the clause whichever is not applicable)
10. The Guarantor represents and confirms that the Guarantor has the legal capacity, power and authority to issue this Guarantee and that giving of this Guarantee and the performance and observations of the obligations hereunder do not contravene any existing laws.

For & on behalf of (Supporting Company)

M/s __________________________

Signature__________________
Name_____________________
Designation_______________
official seal_______________

Witness:
1. Signature________________
Full Name _________________
Address___________________

2. Signature_______________
Full Name _________________
Address___________________

INSTRUCTIONS FOR FURNISHING GUARANTEE

1. The official(s) executing the guarantee should affix full signature(s) on each page.
2. Resolution passed by Board of Directors of the guarantor company authorizing the signatory(ies) to execute the guarantee, duly certified by Company Secretary should be furnished along with Guarantee.
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CERTIFICATE ISSUED BY COMPANY SECRETARY OF THE GUARANTOR COMPANY

“Obligations contained in deed of guarantee No. ______ furnished against tender No. ______ are enforceable against the Guarantor Company and the same do not, in any way, contravene any law of the country of which the Guarantor Company is the subject.”

The above certificate should be enclosed alongwith the Guarantee.
To,
M/s TALCHER FERTILIZERS LIMITED

Dear Sir(s),

M/s. _____________________________________________ (herein after called the "CONTRACTOR/ SUPPLIER/SERVICE PROVIDER" which expression shall wherever the context so require include its successors and assignees) have been placed/ awarded the job/work of _______________________________ vide PO/LOA /FOA No. _______________________________ dated______ (herein after called CONTRACT/ ORDER) for Talcher Fertilizer Limited having registered office at Plot 2/H, Kalpana Area, BJB Nagar, Khurda, Bhubneshwar-751014, Odisha, India (herein after called the “TFL” which expression shall wherever the context so require include its successors and assignees).

Further, M/s __________________ (Name of the Supporting company) having its registered/head office at __________________ based on whose experience/technical strength, the CONTRACTOR/SUPPLIER/SERVICE PROVIDER has qualified for award of contract (hereinafter referred to as the "SUPPORTING COMPANY") which expression shall, unless repugnant to the context or meaning thereof include all its successors, administrators, executors and assignees) has agreed to provide complete technical and other support to the CONTRACTOR/SUPPLIER/SERVICE PROVIDER for successful completion of the contract/order as mentioned above, entered between TFL and the CONTRACTOR/SUPPLIER/SERVICE PROVIDER and TFL having agreed that the "SUPPORTING COMPANY" shall furnish to TFL a performance guarantee for Indian Rupees/US$ ............. towards providing complete financial and other support to the CONTRACTOR/SUPPLIER/SERVICE PROVIDER for successful completion of the contract/order as mentioned above,
The said M/s. ___________________________________________ (Supporting Company) has approached us and at their request and in consideration of the premises we having our office at ______________________________ have agreed to give such guarantee as hereinafter mentioned.

2. We (name of the bank) ______________________________ registered under the laws of _______ having head/registered office at __________________________ (hereinafter referred to as "the Bank", which expression shall, unless repugnant to the context or meaning thereof, include all its successors, administrators, executors and permitted assignees) do hereby guarantee and undertake to pay immediately on first demand in writing any/all moneys to the extent of Indian Rs./US$ (in figures) __________ (Indian Rupees/US Dollars (in words) _______________________) without any demur, reservation, contest or protest and/or without any reference to the 'SUPPORTING COMPANY'. Any such demand made by TFL on the Bank by serving a written notice shall be conclusive and binding, without any proof, on the bank as regards the amount due and payable, notwithstanding any dispute(s) pending before any Court, Tribunal, Arbitrator or any other authority and/or any other matter or thing whatsoever, as liability under these presents being absolute and unequivocal. We agree that the guarantee herein contained shall be irrevocable and shall continue to be enforceable until it is discharged by TFL in writing. This guarantee shall not be determined, discharged or affected by the liquidation, winding up, dissolution or insolvency of the 'SUPPORTING COMPANY' and shall remain valid, binding and operative against the bank.

3. The Bank also agrees that TFL at its option shall be entitled to enforce this Guarantee against the Bank as a principal debtor, in the first instance, without proceeding against the 'SUPPORTING COMPANY' and notwithstanding any security or other guarantee that TFL may have in relation to the 'SUPPORTING COMPANY's liabilities.

4. The Bank further agrees that TFL shall have the fullest liberty without our consent and without affecting in any manner our obligations hereunder to vary any of the terms and conditions of the said CONTRACT/ORDER or to extend time of performance by the said CONTRACTOR/SUPPLIER/SERVICE PROVIDER from time to time or to postpone for any time or from time to time exercise of any of the powers vested in TFL against the said CONTRACTOR/SUPPLIER/SERVICE PROVIDER and to forbear or enforce any of the terms and conditions relating to the said agreement and we shall not be relieved from our liability by reason of any such variation, or extension being granted to the said CONTRACTOR/SUPPLIER/SERVICE PROVIDER or for any forbearance, act or omission on the part of TFL or any indulgence by TFL to the said CONTRACTOR(s) or any such matter or thing whatsoever which under the law relating to sureties would, but for this provision, have effect of so relieving us.
5. The Bank further agrees that the Guarantee herein contained shall remain in full force during the period that is taken for the performance of the CONTRACT/ORDER and all dues of TFL under or by virtue of this CONTRACT/ORDER have been fully paid and its claim satisfied or discharged or till TFL discharges this guarantee in writing, whichever is earlier.

6. This Guarantee shall not be discharged by any change in our constitution, in the constitution of TFL or that of the 'SUPPORTING COMPANY'.

7. The Bank confirms that this guarantee has been issued with observance of appropriate laws of the country of issue.

8. The Bank also agrees that this guarantee shall be governed and construed in accordance with Indian Laws and subject to the exclusive jurisdiction of Indian Courts of the place from where the purchase CONTRACT/ORDER has been placed.

9. Notwithstanding anything contained hereinabove, our liability under this Guarantee is limited to Indian Rs./US$ (in figures) _________________ (Indian Rupees/US Dollars in words) ________________ only) and our guarantee shall remain in force until (indicate the date of expiry of bank guarantee) ________.

8. We have power to issue this guarantee in your favor under Memorandum and Articles of Association and the undersigned has full power to do under the Power of Attorney, dated ___________ granted to him by the Bank.

   Yours faithfully,

   ________________________

   Bank by its Constituted Attorney

   Signature of a person duly Authorized to sign on behalf of the Bank
INSTRUCTIONS FOR FURNISHING
"CONTRACT PERFORMANCE SECURITY / SECURITY DEPOSIT" BY "BANK GUARANTEE"

1. The Bank Guarantee by successful Bidder(s) will be given on non-judicial stamp paper as per 'stamp duty' applicable. The non-judicial stamp paper should be in name of the issuing bank. In case of foreign bank, the said Bank Guarantee to be issued by its correspondent bank in India on requisite non-judicial stamp paper and place of Bid to be considered as Delhi.

2. The Bank Guarantee by Bidders will be given from bank as specified in Tender.

3. A letter from the issuing bank of the requisite Bank Guarantee confirming that said Bank Guarantee and all future communication relating to the Bank Guarantee shall be forwarded to Purchaser.

4. If a Bank Guarantee is issued by a commercial bank, then a letter to Purchaser and copy to Consultant (if applicable) confirming its net worth is more than Rs. 100,00,00,000.00 [Rupees One Hundred Crores] or its equivalent in foreign currency alongwith documentary evidence.
SECTION – IV

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1.0 **SCOPE OF CONTRACT** shall be as per Section VI- 3.0 and Section V of NIT.

2.0 **CONTRACT DOCUMENTS**

The term 'Contract Documents' shall mean and include the following documents which shall constitute the Contract and shall be deemed to form an integral part of the Contract:

a) Contract Agreement  
b) Detailed Letter of Acceptance (DLOA) and all Annexures  
c) FAX OF ACCEPTANCE (FOA)  
d) Post bid Clarification and replies exchanged between Owner and the Contractor  
e) Schedule of Rates  
f) Reply to Pre Bid Queries  
g) Original Tender Document and subsequent amendments, if any  
h) Integrity Pact (IP) signed between the Owner and the Bidder/Contractor

The above documents are intended to be correlative, complementary and mutually explanatory. The Contract shall be read as a whole.

2.1 **INTERPRETATION OF CONTRACT DOCUMENTS**

2.1.1 Notwithstanding the sub-division of the CONTRACT document into these separate documents and/or volumes and/or heads, every part of each separate section/volume/head shall be deemed to be supplementary of every other part and shall be read with and into the CONTRACT so far as it may be practicable to do so.

2.1.2 If in respect of any commercial term or condition, if any provision in the GENERAL CONDITIONS OF CONTRACT is repugnant to or at variance with any provision(s) of the SPECIAL CONDITIONS OF CONTRACT, the provision(s) of the SPECIAL CONDITIONS OF CONTRACT shall be deemed to override the provision(s) of GENERAL CONDITIONS OF CONTRACT, but only to the extent that such repugnancy in the GENERAL CONDITIONS OF CONTRACT cannot be reconciled with the SPECIAL CONDITIONS OF CONTRACT.

2.1.3 Without prejudice to the provisions of the GENERAL CONDITIONS OF CONTRACT, whenever in the Bidding documents it is mentioned or stated that the CONTRACTOR shall perform certain work or provide certain facilities, it is understood that the CONTRACTOR shall do so at his own cost and the Lumpsum Price shall be deemed to have included the cost of such performance and/or provision, as the case may be.

2.1.4 The MATERIALS, design and workmanship shall satisfy the applicable relevant Indian standards, the job specifications contained herein and the codes referred to by expression or implication. Where the job specifications stipulate requirements in addition to those contained in the standard codes and specifications, these additional requirements shall also be satisfied. In the absence of any standard/specification/code of practice for detailed specifications covering any part of the work covered in this tender, the instructions/directions agreed between OWNER and CONTRACTOR based on good international engineering practice shall be binding on the CONTRACTOR.
2.1.5 In the event of any ambiguity or conflict between the Contract Documents listed in clause 2.0 above, the order of precedence shall be the order in which the Contract Documents are listed in Clause 2.0 (CONTRACT DOCUMENTS) above.

2.1.6 Should there be any doubt or ambiguity in the interpretation of the CONTRACT documents or contradiction therein or should there be any discernable error or omission in any CONTRACT document, the CONTRACTOR shall, prior to commencing the relative work or supply, as the case may be, apply in writing to the Engineer-In-Charge for his decision for resolution of the doubt, ambiguity or contradiction or correction of the error or making good the omission, as the case may be. Should the CONTRACTOR fail to apply to the ENGINEER-IN-CHARGE for his decision as aforesaid prior to commencing the relative work or supply, the CONTRACTOR shall perform the said work or make the said supply, as the case may be, at his own risk, and the provisions of Clause 2.1.9 hereof shall apply to any such work performed or supply made by the CONTRACTOR.

2.1.7 Notwithstanding anything provided in Clause 2.1.6 hereof above, either the CONTRACTOR or any representative of the OWNER or CONSULTANT may, at any time prior to or during the execution of the work or supply of any material or any part thereof (if the CONTRACTOR has failed to make an application as provided for in Clause 2.1.6), apply to the ENGINEER-IN-CHARGE in writing for his decision in resolution of any doubt, ambiguity or contradiction or for the correction of any error or for making good the omission as the case may be.

2.1.8 The decision of the ENGINEER-IN-CHARGE on any application under Clause 2.1.6 or Clause 2.1.7 hereof shall be in writing and shall be final and binding upon the CONTRACTOR and shall form part of the CONTRACT documents, with the intent that the CONTRACT documents shall be read as though the said decision is and was at all times incorporated therein. It is clarified that in case the Contractor disagrees with the decision of the ENGINEER-IN-CHARGE, the dispute shall be settled as per the provisions of Clause 39.0 of GCC.

2.2 Any work or supply shown, indicated or included in any description of the work, plans, drawings, Specifications and/or Price Schedule or other Contract or Bid documents shall be deemed to form part of the WORK and/or supply contracted for, as the case may be, notwithstanding failure to show, indicate or include such work or supply in any other or others among the documents aforesaid with the intent that the indication or inclusion of the work or supply within any one of the said documents shall be deemed to be a sufficient indication or inclusion of the work or supply, as the case may be, within the work and supply covered by the CONTRACT.

2.3 No verbal agreement, assurance, representation or understanding given by any employee or officer of the OWNER or so understood by the CONTRACTOR, whether given or understood before or after the execution of the contract, shall any-wise bind the OWNER or alter the CONTRACT documents unless specifically given in writing and signed by the OWNER or by the ENGINEER-IN-CHARGE on behalf of the OWNER and issue the amendment of the relative term(s).

2.4 Clause headings given in this or any other contract documents are intended only as a general guide for convenience in reading and segregating the general subject of the various Clauses, but do not form part of the contract documents, with the intent that the Clause headings shall not govern the meaning or import of the Clauses there under appearing or confine or otherwise affect the interpretation thereof.
3.0 DEFINITION OF TERMS AND INTERPRETATION

In the CONTRACT, unless the context otherwise requires, the following expressions shall have the following meanings. The singular shall include the plural and the plural include the singular except where the context otherwise requires and the words ‘he’, ‘him’, and ‘his’ shall be taken to mean ‘she’, ‘her’ and ‘hers’ where appropriate.

1. ‘APPROVAL’ shall mean and include the written approval by the OWNER of a documents, drawing or other particulars in relation to this CONTRACT.

2. 'BATTERY LIMIT’ shall mean the outer limits of boundaries of the areas within which the Plants and associated facilities shall be located.

3. ‘BID’ shall mean the proposal/document that the BIDDER submits in the requested and specified form in the specification in response to this NIT.

4. 'BIDDER' shall mean the Sole Bidder who shall submit or who have submitted the Bid.

5. ‘CHANGE ORDER’ means an order by which a change is ordered or other notification made to the Contractor in accordance with the CONTRACT.

6. ‘CODES’ shall mean the following, including the latest amendments, and/or replacements, if any:
   a) All relevant Indian Acts, and Rules and Regulations made there under;
   b) ASME Codes
   c) IBR Codes
   d) AIEE Codes
   e) American Society of Testing of Materials (ASTM) Codes
   f) Other internationally applicable standards and/or Regulations the subject matter of the CONTRACT.
   g) Indian Employees Provident Fund Act,
   h) Pollution Control norms of INDIA
   i) Contract Labour
   j) Minimum Wages Act
   k) Any other labour laws of INDIA applicable during execution of contract.
   l) Any other codes/standards specified in the contract documents.

7. 'COMMERCIAL OPERATION' shall mean the condition of operation in which the complete PLANT covered under the CONTRACT is officially declared by the OWNER to be available for continuous operation at different loads upto and including rated capacity after completion of commissioning as per CONTRACT. Such declaration by the OWNER however, shall not relieve
or prejudice the CONTRACTOR any of his obligations under the CONTRACT.

8. ‘COMMERCIAL USE’ shall mean that use of the PLANT which the CONTRACT contemplates or of which it is commercially capable.

9. ‘COMMISSIONING’ shall mean the putting into operation of PLANT by CONTRACTOR including Sustained Load Test as defined under Section-VI of NIT.

10. Deleted

11. ‘CONSULTANT/PROJECT MANAGEMENT CONSULTANT (PMC)’ shall mean the agency nominated/appointed by the OWNER for this project/job/WORKS.

12. 'CONTRACT' shall mean the Agreement between the OWNER and the CONTRACTOR for the execution of the works including therein all contract documents.

13. 'CONTRACTOR’ shall mean the successful Bidder whose bid has been accepted by the OWNER and who has been selected by the OWNER for the award of Works and shall include his heirs, legal representatives, successors and permitted assigns.

14. ‘COMPLETION PERIOD / GURANTEED COMPLETION DATE’ shall mean the time period / date (or as may be extended by the OWNER from time to time) during which the CONTRACT shall be executed.

15. ‘CONTRACTOR’S EQUIPMENT’ means all equipment, construction plant, vehicles, temporary facilities, material, tools or things brought on to the Site by or on behalf of the Contractor for carrying out the Works but not for permanent incorporation in the Plant.

16. ‘CONTRACTOR’S SOFTWARE’ means standard Software owned by the CONTRACTOR.

17. 'CONTRACTOR'S WORKS' OR 'MANUFACTURER'S WORKS' shall mean the place or places of work used by the CONTRACTOR/SUB-CONTRACTOR/SUB-VENDOR or their collaborator(s) for the manufacture of EQUIPMENT or performance of WORKS.

18. ‘COST’ means the cost incurred by the Contractor in carrying out any of his obligations under the Contract, and ‘Costs’ shall be construed accordingly.

19. 'DAY' shall mean a day of 24 hours from midnight to midnight irrespective of the number of hours worked in that day.

"WORKING DAY" means any day which is not declared to be holiday or rest day by the OWNER.
20. ‘DEEMED ACCEPTANCE’ shall mean as defined in Clause 16.0 of SPECIAL CONDITIONS OF CONTRACT.

21. ‘DEFECT’ means any work done or any Material or the Plant or any part of it which does not comply with the CONTRACT.

22. ‘DEFECT/DEFECTS LIABILITY PERIOD’ shall mean a period of 12 months commencing from the date of PRELIMINARY ACCEPTANCE. CONTRACTOR shall warrant that the equipment and material supplied under the CONTRACT shall be new and free from any defect or deficiency with respect to design, material and workmanship. In the event of any defect or deficiency arising during the DEFECT LIABILITY PERIOD, CONTRACTOR shall repair or replace the defective or deficient equipment and materials at its own cost. In such event the defect liability period for the particular equipment shall be another 12 months from the date of acceptance by OWNER of such replaced/repaired equipment/material. However, extended DEFECT LIABILITY PERIOD shall have an upper limit of 24 months for extended DEFECT LIABILITY PERIOD, starting from the Preliminary Acceptance.

23. ‘DOCUMENT(S)/DOCUMENTATION’ means any relevant documents in paper or electronic form, including drawings, technical software, images, designs, manuals or records.

24. 'DRAWINGS' or 'PLAN' shall mean all:
   a) Drawings furnished by the OWNER as a basis for proposals;
   b) Supplementary drawings furnished by the OWNER to clarify and to define in greater detail the intent of the CONTRACT;
   c) DRAWINGS submitted by the CONTRACTOR with his proposal provided such drawings are acceptable to the OWNER.
   d) DRAWING furnished by the OWNER to the CONTRACTOR during the progress of the works; and
   e) Engineering data and DRAWINGS submitted by the CONTRACTOR during the progress of the work provided such drawings are acceptable to the OWNER.

25. DLOA shall mean DETAILED LETTER OF ACCEPTANCE which shall be issued to successful bidder after issuance of FAX OF ACCEPTANCE (FOA).

26. 'ENGINEER'S INSTRUCTIONS' shall mean any drawings and/or instructions in writing, details, directions and explanations issued by the OWNER from time to time during the COMPLETION PERIOD to the CONTRACTOR/ SUB-CONTRACTOR for carrying out the WORK.

27. ENGINEER IN CHARGE" shall mean the person designated from time to time by the OWNER and shall include those who are expressly authorized by him to act
for and on his behalf for operation of this CONTRACT.

28. ‘EQUIPMENT’ OR ‘STORES’ shall mean the equipment, machinery and structure of any kind which the CONTRACTOR is obliged to design, supply, deliver, unload, store at site, erect, set to work and test under the CONTRACT.

29. ‘FINAL ACCEPTANCE’ shall mean that date when all of the conditions set forth in Clause 19 of SPECIAL CONDITIONS OF CONTRACT have been satisfied, all liabilities and obligations under this CONTRACT have been discharged, except those specially to be continued or performed after FINAL ACCEPTANCE.

30. ‘FINAL ACCEPTANCE CERTIFICATE’ shall mean that certificate issued by the ENGINEER-IN-CHARGE or OWNER to the CONTRACTOR subject to clause 19 of SPECIAL CONDITIONS OF CONTRACT at the end of the DEFECTS LIABILITY PERIOD.

31. ‘FINAL COMPLETION’ shall mean the completion of guarantee tests and handing over of the PLANTS and facilities to OWNER.

32. FINAL PROPOSAL means the Offer submitted by the Bidder and its subsequent clarification/revision during techno-commercial queries.

33. ‘FORCE MAJEURE’ has the meaning stated in Sub-clause 35.0 of GCC.

34. ‘FOA’ means Fax of Acceptance.

35. GCC or GENERAL CONDITIONS OF THE CONTRACT shall mean all the terms and conditions forming part of this agreement as defined in the Section IV.

36. Deleted

37. 'INITIAL OPERATION' shall mean the first integral operation of the complete EQUIPMENT covered under the CONTRACT with sub-systems and supporting equipment in service or available for service and shall be undertaken as part of COMMISSIONING after completion of start up activities.

38. 'INSPECTOR' shall mean the duly authorised representative of the OWNER for stage wise or final inspection of WORKS or of EQUIPMENT or MATERIALS to be supplied under the CONTRACT.

39. ‘LEGISLATION’ means all applicable laws, directives, codes, statutes, rules, ordinances, approvals, licences, decrees, authorizations, by-laws, regulations, standards and any other requirement of any governmental authority or agency whether international national, state, municipal, local or other government subdivision, having the force of law in any place where the WORKS or any part of the WORKS are being carried out.

40. ‘MANUFACTURER’ shall mean a person or firm who is the producer and supplier of material and/or designer and/or fabricator of equipment to either the
OWNER, the CONTRACTOR or both under the CONTRACT.

41. ‘MATERIALS’ means machinery, plant and other items of equipment and materials intended to form part of the PLANT and other things needed for its operation, to be supplied by the CONTRACTOR.

42. "MECHANICAL COMPLETION" shall mean completion of erection to such an extent that the PLANT is ready for commissioning. This shall happen when:

A. The EQUIPMENT capable of producing to rated capacities are installed, aligned and grouted (wherever applicable) in accordance with drawings, specifications as per finally approved P&I Diagrams after HAZOP Studies and in accordance with all applicable codes, and laws.

B. All pressure EQUIPMENT are hydrostatically or pneumatically tested once either in CONTRACTOR'S shop or in the field in accordance with Technical Specifications.

C. Fired Heater and Boilers are hydrostatically or pneumatically tested. All non-operating preferring checks are made in accordance with the manufacturer's instructions.

D. Compressor, Turbine, Generator Pumps, Machinery etc. are cold aligned. Couplings are assembled and guards installed.

E. Instruments, control system, instrument cable, safety interlock are installed, inspected and such non-operating checks are made as to ensure operability in the manner required for the process application. Instrument air lines are checked for correct hook up. Air lines are leak tested.

F. Relief valves are installed prior to this, they will have been checked by the CONTRACTOR in the CONTRACTOR's shop.

G. Piping is hydrostatically or pneumatically tested in accordance with the specifications. Special treatment such as chemical cleaning is done as required by drawing or specifications. Suction screens are installed and test blinds are removed. Spring support anchors and guide are checked for removal of all shipping locks.

H. The electric system is installed and tested in accordance with and to the extent required by electrical specifications. All wiring is checked for correct hook up. Motor rotation is checked. All power system protective devices are set.

I. Insulation and drying out are completed to the extent necessary to permit start of commissioning and start up.
J. Pipe support system installed as per drawings.

K. Painting is completed. EQUIPMENT /MACHINERY, piping duly marked and labelled.

L. Safety equipments, systems are installed and checked for operations. Effluent management and treatment systems are installed and operational.

M. All Emergency & Instrument power system are checked and operating.

N. All chemical & lubricants are charged into the system.

O. PRECOMMISSIONING has been completed.

P. The PLANT is ready to take feed

Q. All packing and bed support materials are installed.

R. Liquidation of all punch list applicable for achieving MECHANICAL COMPLETION. Balance items of punch list, if any, shall be liquidated as mutually agreed

S. Temporary constructions facilities are removed to extent necessary to permit start of commissioning of Plant.

43. 'MONTH' shall mean the calendar month.

44. 'NOTIFICATION OF AWARD OF THE CONTRACT'/FAX OF ACCEPTANCE' refer Clause No. 36 of ITB.

45. 'NOTICE IN WRITING', 'WRITTEN NOTICE' shall mean a notice in written, typed or printed characters sent (unless delivered personally or otherwise proved to have been received) by registered post/ Speed Post to the last known private or business address or registered office of the addressee and shall be deemed to have been received when in the ordinary course of post it would have been delivered. Fax with Post copy confirmation.

46. ‘OTHER CONTRACTOR/OTHERS' shall mean any person(s) having a contract with the OWNER to design, supply, erect, set to work, or do any other thing to or in connection with any other plant and shall include their, heirs, legal representatives, successors and permitted assigns.

47. ‘OWNER’ shall mean M/s Talcher Fertilisers Limited having its registered office at Plot 2/H, Kalpana Area Nagar, Khordha, Bhubaneshwar – 751014 and shall include their, heirs, legal representatives, successors and permitted
assigns.

48. 'PERFORMANCE & GUARANTEE TESTS RUN (PGTR)' shall mean all operational checks and tests required to determine and demonstrate capacity, efficiency and operating characteristics and proving guarantees for work cost as specified in the CONTRACT documents.

49. ‘PLANT’ shall mean the Steam Generation Plant as defined in Section VI-1.0 of NIT.

50. ‘PRELIMINARY ACCEPTANCE’ shall mean that following milestones have been achieved (i) MECHANICAL COMPLETION has occurred, (ii) PRE-COMMISSIONING and COMMISSIONING of the PLANT have been accomplished, (iii) the Sustained Load Test has been passed successfully, (iv) PGTR has been conducted by LSTK Contractor and accepted by OWNER (v) All statutory approvals in the scope of Contractor, required to operate and maintain the PLANT have been obtained (vi) OWNER has received all DOCUMENTS required hereunder to start up, operate and maintain the PLANT (vii) OWNER has received all operations, maintenance, and spare parts manuals and instruction book necessary to operate and maintain the PLANT in a safe, efficient and effective manner (viii) all special tools and spare parts purchased by CONTRACTOR as provided herein have been delivered to OWNER; and (ix) CONTRACTOR has completed the training program of OWNERS personnel as required under this CONTRACT (x) All demonstration runs have successfully completed

51. ‘PRELIMINARY ACCEPTANCE CERTIFICATE’ shall mean that certificate issued by the ENGINEER-IN-CHARGE or OWNER to the CONTRACTOR following satisfaction of conditions under PRELIMINARY ACCEPTANCE, the acceptance of which commences the DEFECT LIABILITY PERIOD.

52. "PRE-COMMISSIONING" shall mean preparation of PLANT so that it is capable of operating on a continuous basis at or near rated capacity for carrying out COMMISSIONING activities.

53. 'PROJECT’ shall mean the Project specified in the Technical specification.

54. Deleted.

55. Deleted

56. Deleted

57. ‘SCC’ or SPECIAL CONDITIONS OF THE CONTRACT shall mean all the terms and conditions forming part of this agreement as defined in the Section V

58. 'SITE' shall mean and include the land and other places on, into or through which the EQUIPMENT and related facilities shall be erected and any adjacent land, paths, streets or reservoirs which may be allocated or used by the OWNER
or CONTRACTOR in the performance of the CONTRACT.

59. ‘SOFTWARE’ means all forms of software and firmware and their documentation.

60. 'SPECIFICATION' shall mean collectively all the terms and stipulations in Conditions of the CONTRACT, the Technical Specifications, schedules, detailed descriptions, statement of Technical Data, performance characteristics, standards & codes etc., and subsequent addenda issued thereto before the date of closing of bid and all written agreements made or to be made pertaining to the method and manner of performing the Work or to the quantities and the qualities of the materials to be furnished under this CONTRACT.

61. 'START UP' shall mean bringing the equipment covered under the CONTRACT from an inactive condition, when construction is essentially complete, to the state ready for initial operation. The start up shall include preliminary inspection and checkout of EQUIPMENT and supporting sub-systems; perform calibration and corrective action and chemical cleaning of the plant/system/equipment covered under the CONTRACT.

62. 'SUB-CONTRACTOR/SUB-VENDOR' shall mean any person or persons, or firm(s) including his/their, heirs, legal representatives, successors and permitted assigns selected by the CONTRACTOR with prior written approval of the OWNER for undertaking any part of the Works under the CONTRACT or to whom any part of the CONTRACT is sublet by the CONTRACTOR with the consent in writing of the OWNER.

63. ‘TAKING OVER’ AND ‘TAKEN OVER’ shall mean OWNER taking possession of and use of the PLANT following issue of PRELIMINARY ACCEPTANCE CERTIFICATE.

64. ‘TEMPORARY WORKS’ means all temporary works and structures of every kind constructed at the Site and required for the provision and construction of the PLANT.

65. 'TEST ON COMPLETION', shall mean all such tests as prescribed in NIT Documents to be performed by the CONTRACTOR have been carried out satisfactorily.

66. ‘THIRD PARTY SOFTWARE’ means standard Software which is owned by a third party.

67. ‘TOTAL CONTRACT PRICE” shall mean the sum accepted or the sum calculated in accordance with the prices accepted in tender and/or the CONTRACT rates as payable to the CONTRACTOR for the entire execution and full completion of the work, including change order.

68. Deleted

69. 'WEEK' shall mean continuous period of 7 (Seven) DAYS.
70. 'WORK' OR 'WORKS' means the design, engineering and other services to be provided by the Contractor including, but not limited to, the provision and construction of the PLANT and any Temporary Works and the subsequent dismantling or removal of the Temporary Works when no longer required, and any other works to be carried out by the CONTRACTOR in accordance with the CONTRACT.

71. 'WRITING' shall include any manuscript, typewritten or printed statement, under or over signature and/or seal as the case may be.

72. ‘NOTICE INVITING TENDER (NIT)/ BIDDING DOCUMENT’ means Complete Bidding Document as originally issued and any Addendum /Corrigendum/ Amendment(s) issued thereafter.

73. ‘MUTUALLY AGREED DAMAGES' (MAD) means the pre-defined mutually agreed rates between OWNER and CONTRACTOR as detailed in NIT representing the ‘CONTRACTOR’s liability (without possibility to recourse at Law) for the delay in achieving GUARANTEED COMPLETION DATE and / or for the failure to meet Works Cost Guarantee provided under Article 31 of GCC for reasons attributable to the CONTRACTOR.

4.0 CONTRACT CONFIRMATION

4.1 On acceptance of the bid of the successful bidder by the OWNER, such bidder shall be issued FAX OF ACCEPTANCE (FOA). The successful bidder will be required to give his unconditional acceptance in writing of FOA within 15 (fifteen) days. Thereafter a CONTRACT AGREEMENT as per format F-14 shall be executed between the OWNER and the BIDDER within fifteen (15) days from date of acceptance of FOA. CONTRACTOR shall sign the CONTRACT AGREEMENT and return it to the OWNER. The copy of the CONTRACT AGREEMENT shall be signed by an authorised officer of the CONTRACTOR in whose name Power of Attorney has been issued.

4.2 A 'DETAILED LETTER OF ACCEPTANCE (DLOA)' shall thereafter be issued by the OWNER.

4.3 If after issuance of FOA, CONTRACTOR fails to deposit the SECURITY CUM PERFORMANCE BANK GUARANTEE within the time period specified in the CONTRACT, the OWNER reserves the right to cancel the CONTRACT and forfeit the EMD without prejudice to various rights and remedies the OWNER may be entitled to as per terms and conditions of CONTRACT and without being liable in any manner whatsoever to the CONTRACTOR.

4.4 The DLOA and CONTRACT AGREEMENT will be signed in duplicate, one copy each for CONTRACTOR and OWNER.

5.0 MODIFICATIONS IN CONTRACT

5.1 All modifications leading to changes in the CONTRACT with respect to technical or commercial aspects including terms of completion period shall be considered valid only when accepted in writing by OWNER and CONTRACTOR by issuing amendment to the
CONTRACT. Issuance of acceptance or otherwise in such cases shall not be any ground for extension of agreed completion date (except in cases where completion period itself is revised by OWNER) and also shall not affect the performance of CONTRACT in any manner except to the extent mutually agreed to, through a modification to CONTRACT. The PARTIES shall have the right to modify or amend the CONTRACT subject to an adjustment in the CONTRACT PRICE and/ or COMPLETION DATE in accordance with the applicable provision of the CONTRACT, if any, and subject to mutual agreement.

5.2 OWNER shall not be bound by any printed conditions or provisions in the CONTRACT-OR's bid forms or acknowledgement of CONTRACT, packing list and other documents which support to impose any condition at variance with or supplemental to CONTRACT.

6.0 USE OF CONTRACT DOCUMENTS AND INFORMATION

6.1 The CONTRACTOR shall not, without the OWNER's prior written consent, disclose the CONTRACT or any provision thereof, or any specification, plan, drawing, pattern, sample or information furnished by or on behalf of the OWNER in connection therewith, to any person other than a person employed by the CONTRACTOR in the performance of the CONTRACT. Disclosure to any such employed person shall be made in confidence and shall extend only so far as may be necessary for purpose of such performance.

6.2 The CONTRACTOR shall not without the OWNER's prior written consent, make use of any document or information enumerated in Clause 6.1 except for purpose of performing the CONTRACT.

6.3 Any document other than CONTRACT, itself, enumerated in Clause 6.1 shall remain the property of the OWNER and shall be returned (all copies) to the OWNER on completion of the CONTRACTOR's performance under the CONTRACT if so required by the OWNER.

7.0 PATENT INFRINGEMENT AND INDEMNIFICATION

7.1 PATENT INFRINGEMENT

7.1.1 CONTRACTOR shall at all times, indemnify and keep indemnified OWNER against all claims or suits and defend, at its own cost, any suit or action brought against OWNER and hold OWNER free and harmless against all costs of such claims or suits which may be made against OWNER in respect of any infringement of any rights protected by patent, copyright, trademarks, and trade secrets to the extent that such claim, suit, or action is a result of the use of CONTRACTOR's Technical Information for the construction, maintenance, and operation of PLANT and the use of CONTRACTOR's and/or any other process licenser's processes used in PLANT. OWNER shall pass on all claims made against it to CONTRACTOR for settlement.

7.1.2 CONTRACTOR declares that to the best of its knowledge and belief the use of CONTRACTOR's Technical Information for the construction, maintenance, and operation of PLANT and the use of CONTRACTOR's processes used in PLANT will not infringe any valid patent rights of a third party. However, if at any time such infringement arises, CONTRACTOR agrees to keep OWNER indemnified and harmless against such claims and costs thereof and make arrangements that will allow OWNER to continue the operation of PLANT.
OWNER shall promptly advise CONTRACTOR in writing of any claim of infringement or any action for infringement of patents brought against it by a third party and based upon the use of CONTRACTOR's Technical Information. If such use is in accordance with instructions given in writing by CONTRACTOR, CONTRACTOR shall undertake the defence, or assist OWNER in the defence, of the claim or suit up to final judgment or settlement.

CONTRACTOR shall undertake the defence on behalf of OWNER and shall have sole charge and direction of the defence, and shall bear all costs related thereto. CONTRACTOR shall further hold OWNER harmless from any damages or other sums that may become payable by OWNER under a final judgment or settlement. However, OWNER shall render to CONTRACTOR all reasonable assistance that may be required by CONTRACTOR in the defence, and shall have the right to be represented therein by advisory counsel of its own selection and at its own expense.

In addition to the measures specified in Clause-7.1.4, CONTRACTOR may further, at its option, however, in reasonable consultation with OWNER, seek to abate the alleged infringement by modification of PLANT or its operation without adversely affecting the performance and/or secure for OWNER immunity from suit for infringement. In such case, CONTRACTOR shall bear/ reimburse OWNER for all costs related to said modification and to said immunity.

In the event that OWNER is legally restrained from operating PLANT on account of any infringement action or suit, CONTRACTOR shall take all possible actions to allow OWNER to operate and use PLANT.

Neither CONTRACTOR nor OWNER shall settle or compromise any suit or action without the written consent of the other if settlement or compromise obliges the other to make any payment or part with any property or assume any obligations or surrender any rights or to be subjected to any injunction by reason of such settlement or compromise.

INDEMNITIES

INDEMNIFICATION FOR LIABILITIES

CONTRACTOR Indemnification for Liabilities

To the fullest extent permitted by Law, CONTRACTOR assumes liability for and agrees to indemnify, protect, save and hold harmless OWNER from and against any and all Liabilities (including, any strict liability), arising out of acts or omissions of CONTRACTOR or its personnel or its agents in the performance of its obligations under the CONTRACT causing bodily injury, sickness, disease or death, damage to or loss of any property, and whether or not involving damage to WORKS or SITE that may be imposed on, suffered or incurred by or asserted against OWNER and in any way relating to or arising out of (i) WORK, any EQUIPMENT (ii) the presence, discharge, treatment, storage, transportation, disposal, escape or release of any Hazardous Substance, or the threat thereof, at, to or from SITE after commencement of work (any hazardous substance already existing at SITE before commencement of WORK excluded) (iii) The performance of WORK, or as a result of personal injuries (including wrongful death); (iv) the violation by CONTRACTOR or any SUB-CONTRACTOR/VENDOR of any Government Approval or applicable Law relating to WORK (v) any breach of CONTRACT with any SUB-CONTRACTOR/VENDOR, provided, however, that CONTRACTOR shall not be required
under this Clause to indemnify OWNER for any liability arising out of or resulting from events or circumstances occurring or existing after PRELIMINARY ACCEPTANCE OF PLANT except where the liability arises from an act or omission of CONTRACTOR or any SUB-CONTRACTOR/VENDOR or any other Person directly or indirectly employed by either of them or anyone for whose acts either of them may be liable that was a contributory cause of such liability.

7.2.2 **CONTRACTOR Indemnification for Taxes**

It is specifically understood that CONTRACTOR hereby accepts and assumes exclusive liability for and save and hold OWNER harmless from and against all Taxes arising from the performance of WORK, and all such Taxes shall be deemed to be included in CONTRACT PRICE.

7.2.3 **Indemnification by SUB-CONTRACTOR/VENDOR**

CONTRACTOR shall obtain from each SUB-CONTRACTOR/VENDOR, which is an affiliate, and shall use all reasonable efforts to obtain from each SUB-CONTRACTOR/VENDOR, an indemnification materially similar in form and substance to Clause-7.1 and Clause-7.2.2 of which the OWNER shall be named as beneficiary.

7.2.4 **Payment of Amounts under this Clause**

Except to the extent covered by insurance, all amounts payable and due by CONTRACTOR to OWNER under this Clause shall be deducted from CONTRACT PRICE or any other amounts owed by OWNER to CONTRACTOR here under. If such amounts payable by OWNER to CONTRACTOR are less than the amounts payable and due by CONTRACTOR under this Clause, CONTRACTOR shall be liable to OWNER for such excess and shall pay such amount to OWNER immediately upon demand.

7.2.5 **Permits and Certificates**

CONTRACTOR shall procure, at its expense, all necessary permits, certificates and licences required by virtue of all applicable laws, regulations, ordinances and other rules in force at the place where any of the works is to be performed, and CONTRACTOR further agrees to hold OWNER harmless from liability or penalty which might be imposed by reason of any asserted or established violation of such laws, regulations, ordinances or other rule. OWNER shall provide the necessary permits for CONTRACTOR's personnel to undertake any work in India in connection with CONTRACT.

7.2.6 **Mechanics Lien**

CONTRACTOR agrees to indemnify and hold harmless OWNER against all labourer's material, man's and/or mechanic's liens arising from its work, and shall keep the premises of OWNER free from all such claims, liens and encumbrances.

8.0 **CONTRACT PERFORMANCE SECURITY (CPS)**

8.1 The proceeds of **CPS** shall be appropriated by the OWNER as compensation for any loss resulting from the CONTRACTOR's failure to complete their obligations under the
CONTRACT without prejudice to any of the rights or remedies the OWNER may be entitled to as per terms and conditions of the CONTRACT.

8.2 The CPS shall be valid upto DEFECT LIABILITY PERIOD plus three months. The CONTRACTOR shall extend the validity of the CPS suitably if it is required due to delay in PRELIMINARY ACCEPTANCE of the PLANT at its own cost. The CPS shall be suitably extended in event of repair/replacement of equipment or any part thereof during DEFECT LIABILITY PERIOD to take care of extended warranty period of repair/replacement. The proforma for this bank guarantee is enclosed as F-4. The Bank Guarantee will be discharged by the OWNER after the CONTRACTOR's performance obligation including any warranty obligation under the CONTRACT. For any component replaced during DEFECT LIABILITY PERIOD, the component should work satisfactorily for a period of 12 months from the date of replacement.

The CPS shall be retained by OWNER during the currency of CONTRACT as indicated above, or till settlement of all the accounts thereof whichever is later. In case of any dispute or differences not settled within the validity of CPS, contractor shall arrange to get the CPS extended for the period asked for by OWNER. In case CPS is not extended as asked, OWNER shall have the sole discretion to 'call in' the bank to pay the whole or part of the amount of bank guarantee/CPS. The above deposit shall be deemed to be security for the faithful performance of the CONTRACT and for the purpose of section 74 of the Indian Contract Act, 1872 and for the extension of that section, the CPS shall deemed to be the bond given by the CONTRACTOR for the performance of essential duty. In the event of breach of any of the terms and conditions of the contract, OWNER shall have the right to draw from the CPS whole or part of the value of CPS. The amount so drawn shall not in any way affect any remedy to which OWNER may otherwise be entitled or any liability incurred by contractor under the contract or any law for the time being in force relating thereto or bearing here upon. This CPS shall be refunded 3 months after expiry of Defect Liability Period. It shall be lawful for OWNER if any differences or dispute is likely to arise to defer payment of the CPS or any portion thereof which may be due for release until such differences and dispute has been finally settled or adjusted. CPS amount shall not bear any interest.

NOTE:

In case CPS is submitted by way of Bank Guarantee, the non-judicial Stamp paper of appropriate value only or equivalent document value shall have to be purchased in the name of the bank executing the bank guarantee and not in the name of the CONTRACTOR.

8.3 Rights of the OWNER to forfeit CPS:

i) Whenever any claim against the CONTRACTOR for the payment of a sum of money arises out or under the CONTRACT, the OWNER shall be entitled to recover such sum by appropriating in part or whole the CPS of the CONTRACTOR. In the event of the security being insufficient or if no security has been taken from the CONTRACTOR, then the balance or the total sum recoverable, as the case may be shall be deducted from any sum then due or which at any time thereafter may become due to the CONTRACTOR. The CONTRACTOR shall pay to the OWNER on demand any balance remaining due.
ii) All compensation or other sums of money payable by the CONTRACTOR to the OWNER under terms of this CONTRACT may be deducted from or paid by the encashment or sale of a sufficient part of his CPS or from any sums which may be due or may become due to the CONTRACTOR by the OWNER of any account whatsoever and in the event of his Rights of the OWNER to forfeit CPS.

9.0 DELETED

10.0 MANNER OF EXECUTION OF CONTRACT

10.1 All documents as per Clause 2.0 of GCC shall be included in the DLOA.

10.2 Every page of the CONTRACT agreement shall be initialled by the authorised representatives of OWNER and CONTRACTOR under the Seal of their respective Companies.

10.3 The CONTRACT agreement shall be prepared on Non-Judicial stamp paper of appropriate value as per specified Form of Contract as per format F-14. Cost of Non-Judicial stamp paper shall be borne by CONTRACTOR.

10.4 The CONTRACTOR shall present the above CONTRACT AGREEMENT so prepared in two Sets along with proper Power of Attorney and other requisite material on the day of signing the agreement.

10.5 Notwithstanding anything mentioned in any other clause, any conditions imposed from time to time by Government of India shall be followed by the CONTRACTOR.

11.0 Deleted

12.0 ASSIGNMENT OR SUBLETTING OF CONTRACT AND SUB-CONTRACTING

12.1 Neither CONTRACTOR nor OWNER shall assign CONTRACT or any part of it or any share of interest therein, without the prior written consent of the other party. This consent shall not be unreasonably denied.

12.2 CONTRACTOR shall not subcontract the whole or any part of WORK without the prior written consent of OWNER provided always that CONTRACTOR may subcontract any part of WORK to any of its affiliates or subsidiaries in which event CONTRACTOR shall remain fully responsible to OWNER for the work performed by such affiliates.

12.3 Sub-Contracts and Purchase Orders

12.3.1 General
All vendors, suppliers, consultants and SUB-CONTRACTORS/ SUB-VENDORS providing equipment, materials, construction equipment, or services to CONTRACTOR under a
SUBCONTRACT, purchase order or similar purchase form or arrangement with CONTRACTOR for the performance of the WORK under this CONTRACT are herein referred as "SUB-CONTRACTORS"/ "SUB-VENDORS", and any such SUB-CONTRACTS, purchase orders and similar purchase forms and arrangement entered into by or on behalf of CONTRACTOR with SUB CONTRACTORS/SUB-VENDORS are herein referred to as "SUB-CONTRACTS" provided that none of OWNER's CONTRACTOR'S or SUB-CONTRACTOR'S/ SUB-VENDOR'S shall be deemed to be a SUB-CONTRACTOR/ SUB-VENDOR under the CONTRACTOR. The CONTRACTOR shall be obligated to select SUB-CONTRACTORS/ SUB-VENDORS it retains in connection with the performance by CONTRACTOR of the WORK from the SUB-CONTRACTOR'S/ SUB-VENDOR'S list which would be finalised and approved by the OWNER. OWNER and CONTRACTOR may by mutual agreement add to or delete from such list from time to time and approve any successor or replacement of any person listed on such list or any other vendor, supplier, material-man, consultant or SUB-CONTRACTOR/ SUB-VENDOR.

12.3.2 Approval of Major SUB-CONTRACTOR/SUB-VENDOR

12.3.2.1 The vendor list for procurement of EQUIPMENT and the list of SUB-CONTRACTOR/ SUB-VENDOR shall be as attached in the Section VI of NIT. Any changes to such list of SUB-CONTRACTOR/SUB-VENDOR shall require the prior approval of OWNER. CONTRACTOR shall provide name, address, fax number and name of contact person of major SUB-CONTRACTORS/SUB-VENDORS for use in future, to OWNER. SUB-CONTRACTOR/SUB-VENDOR as per agreed Vendor list are not subject to approval.

12.3.2.1.1 Under normal circumstance a bidder shall not be allowed to source any equipment/machinery from the vendors other than the Owners approved vendor list. However, in exceptional circumstance the bidder may suggest additional vendors meeting the following requirement for the approval of Owner.

   a. The BIDDER should specify, while pre-qualifying the Vendors, that during the past 7 years the Vendor should have supplied at least two similar plant equipments or machinery. The BIDDER should satisfy themselves that sufficient documentary proof is submitted by the Vendors in support of this criterion. However, in case of critical equipment, in addition to above criterion, the Vendor should also be prequalified by Process Licensor.

   b. The Bidder would be ultimately responsible for verifying the credentials, the quality of the equipment, machinery and timely supply.

12.3.2.2 The review, approval and consent by OWNER as to the agreed SUB-CONTRACTOR's/SUB-VENDOR List or as to CONTRACTOR's entering into any SUB-CONTRACT / PURCHASE ORDER shall not relieve CONTRACTOR of any of its duties, liabilities or obligations under this CONTRACT and CONTRACTOR shall be liable hereunder to the same extent as if any such Subcontract had not been entered into.

12.3.2.3 (a) CONTRACTOR shall provide to OWNER such information concerning the SUB-CONTRACTORS as OWNER may from time to time reasonably request and shall ensure that each SUBCONTRACT contains provisions in all material respects not less stringent than the provisions of the CONTRACT and shall include terms and provisions required to be included...
pursuant to the CONTRACT. In the event of termination of the CONTRACT under Clause 34.0 herein, CONTRACTOR shall forthwith deliver to OWNER a copy of each SUBCONTRACT.

(b) CONTRACTOR shall supervise and direct the work of all SUBCONTRACTORS/SUB-VENDORS and shall be responsible for all design, engineering, procurement, manufacturing, transportation, delivery, fabrication, construction, commissioning, start-up and testing means, erection, operation, maintenance, repair, methods, techniques, sequences and procedures of, and for co-coordinating the work of SUB-CONTRACTORS/ SUB-VENDORS.

(c) If CONTRACTOR fails to correct, or commence to correct and execute the correction with due diligence of deficient or defective work performed by any SUB-CONTRACTOR/SUB-VENDORS within reasonable time (provided it doesn’t materially impact safe operation of plant), after receipt by CONTRACTOR of a notice from OWNER with respect thereto, OWNER may (but shall not be obligated to), after seven days following receipt by CONTRACTOR of an additional notice, and without prejudice to any other right or remedy take all reasonable steps to remedy such defective or deficient work at risk and cost of CONTRACTOR.

(d) CONTRACTOR shall require all SUB-CONTRACTORS/SUB-VENDORS to perform the SUB-CONTRACTS in accordance with the relevant requirements of the CONTRACT including FINAL PROPOSAL, all APPLICABLE LAWS and APPLICABLE PERMITS, Prudent Utility Practice, Good Engineering Practices, the requirements of the NIT, and all Warranties of SUB-CONTRACTORS/SUB-VENDORS and Manufacturers and all insurance policies relating to the PLANT or the WORK.

(e) CONTRACTOR shall be solely responsible for paying each SUB-CONTRACTOR/SUB-VENDOR and any other person to whom any amount is due from CONTRACTOR for services, equipment, construction equipment, materials or supplies otherwise related to the PLANT or the WORK. CONTRACTOR shall take all reasonable steps and actions to ensure that such services, equipment, construction equipment materials and supplies and the like have been or will be received, inspected and approved and that such services have been or will be properly performed.

(f) In performing the duties incidental to its responsibilities hereunder, CONTRACTOR shall issue to the SUB-CONTRACTORS/SUB-VENDORS such directives and impose such restrictions as may be required to obtain such compliance herewith and with the terms of the SUB-CONTRACTS.

12.3.2.4 SUB-CONTRACTOR/VENDOR AND MANUFACTURER WARRANTIES

(a) CONTRACTOR shall ensure that all equipment and other items used in connection with the performance of the WORK or incorporated in the PLANT (other than minor items) will be purchased in compliance with CONTRACT Technical Specifications and requirements in order to allow the Plant to achieve the Guarantee and Warrantee as provided for in the CONTRACT, unless otherwise agreed with OWNER. Any residual warranty from subcontractor/vendor shall be passed to the OWNER after expiry of DEFECT LIABILITY PERIOD.

(b) Neither CONTRACTOR nor its SUB-CONTRACTORS/SUB-VENDORS nor any
person under the control of either thereof, shall take any action which could release, void, impair or waive any Guarantee or Warranty on EQUIPMENT or services relating to the PROJECT or the WORK. Any residual warranty from sub-contractor/sub-vendor shall be passed to the OWNER after expiry of DEFECT LIABILITY PERIOD.

(c) Nothing in this clause shall derogate from the obligations of CONTRACTOR to provide the Guarantees and Warranties described in and to comply with the provisions hereinabove.

(d) CONTRACTOR shall, based on its past professional judgement enforce all guarantees and warranties provided hereunder to the fullest extent thereof till such time they are transferred to the OWNER pursuant to sub-clause (g) below.

(e) Upon the expiration or termination of any of the guarantees or warranties provided by CONTRACTOR pursuant to the CONTRACT, the CONTRACTOR shall assign, and hereby assigns, effective as of such date, or otherwise make available, to OWNER all of CONTRACTOR's rights under all such SUBCONTRACTOR's residual Guarantees and Warranties as per 12.3.2.4(a) & (b) (except to the extent CONTRACTOR has thereof provided warranty services to OWNER and is enforcing CONTRACTOR's rights with respect to such services under the applicable guarantee or warranty) and shall deliver to OWNER copies of all contracts providing for such guarantees and warranties.

(f) CONTRACTOR, in accordance with the CONTRACT, shall require all SUBCONTRACTORS/SUB-VENDORS to be covered by the insurance covers specified in the CONTRACT, during the time in which they are engaged in performing WORK.

(g) CONTRACTOR shall require all SUB-CONTRACTORS/SUB-VENDORS to release and waive any and all rights of recovery against OWNER including its affiliates, subsidiaries, employees, successors, permitted assigns, insurers and underwriters) and against CONTRACTOR and all other SUB-CONTRACTORS/ VENDORS which the releasing SUB-CONTRACTOR/ VENDOR may otherwise have or acquire, in or from or in any way connected with any loss covered by policies of insurance maintained or required to be maintained pursuant to this the CONTRACT (other than third party liability insurance policies) or because of deductible clauses in or inadequacy of limits of any such policies of insurance. CONTRACTOR shall further require all SUB-CONTRACTORS/VENDORS to include in all policies of insurance maintained by the SUB-CONTRACTORS/VENDORS clauses providing that each underwriter shall release and waive all of its rights of recovery, under subrogation or otherwise, against OWNER, its promoters, affiliates, subsidiaries, employees, successors, permitted assigns, insurers and underwriters, and against CONTRACTOR and all other SUB-CONTRACTORS/VENDORS.

(h) OWNER shall not be deemed by virtue of the CONTRACT to have any contractual obligation to or relationship with any SUB-CONTRACTOR/VENDOR.
12.3.2.5 CONTRACTOR's LIABILITY FOR APPROVED SUB CONTRACTOR:

The review by and approval and consent of OWNER as to the approved SUB-CONTRACTORS list or as to CONTRACTOR entering into any SUB-CONTRACT with any approved SUB-CONTRACTOR or as to any WORK done or supply made or services provided by any such approved SUB-CONTRACTOR/ SUB-VENDOR shall not relieve CONTRACTOR of any of his duties, liabilities or obligations under this CONTRACT, and CONTRACTOR shall be liable hereunder to the same extent as if any such SUB-CONTRACT had not been entered into. Any inspection review or approval by OWNER permitted under this CONTRACT of any portion of the work or of any work in progress by CONTRACTOR or SUB-CONTRACTORS/ SUB-VENDORS shall not relieve CONTRACTOR of any duties, liabilities or obligations under this CONTRACT.

12.3.3 All WORK performed or EQUIPMENT supplied by SUB-CONTRACTOR/ SUB-VENDOR shall be pursuant to an appropriate SUB-CONTRACT, PURCHASE ORDER or similar agreement which shall, as appropriate, contain provisions that:

12.3.3.1 Preserve and protect all the rights of OWNER here under for WORK to be performed or EQUIPMENT to be supplied under PURCHASE ORDER or SUB-CONTRACT.

12.3.3.2 Require that such WORK be performed or EQUIPMENT be fabricated, supplied and installed in strict accordance with the applicable requirements of this CONTRACT.

12.3.3.3 Obligate such SUB-CONTRACTOR/SUB-VENDOR to consent to and be bound by those obligations under this CONTRACT which by their terms are intended to also obligate such SUB-CONTRACTOR/VENDOR, including the provisions of this Clause.

12.3.3.4 Require such SUB-CONTRACTOR/ SUB-VENDOR to provide and maintain adequate insurance consistent with requirements for companies of similar size and performing similar services. Permit the assignment of such SUB-CONTRACT/PURCHASE ORDER by CONTRACTOR to OWNER.

12.3.4 CONTRACTOR RESPONSIBLE FOR WORK

12.3.4.1 CONTRACTOR is responsible for WORK, and that the performance thereof conforms in all respects to the requirements of this CONTRACT, regardless of any failure of any SUB-CONTRACTOR/VENDOR to perform or any disagreement between any SUB-CONTRACTOR/VENDOR or between any SUB-CONTRACTOR/VENDOR and CONTRACTOR. CONTRACTOR shall furnish such information relative to its SUB-CONTRACTOR/VENDOR (including copies of unpaid SUB-CONTRACT or PURCHASE ORDER) as OWNER may request.

12.3.5 DAMAGES

12.3.5.1 It is within the discretion of Contractor, that CONTRACTOR shall agree to hold all SUB-CONTRACTOR/VENDOR, including all persons directly or indirectly employed by them, responsible for any damages due to breach of CONTRACT caused by them or any negligent act and to diligently endeavour to effect recoveries in such damages.
13.0 STANDARDS

The goods and services supplied under this CONTRACT shall conform to the standards mentioned in the technical specifications and when no applicable standard is mentioned, CONTRACTOR to follow best engineering practices.

14.0 INSTRUCTIONS, DIRECTIONS

14.1 The materials described in CONTRACT are to be supplied according to the standards, data sheets, tables, specifications and drawings attached hereto and/or enclosed with the CONTRACT itself and according to all conditions both general and specific enclosed with the CONTRACT, unless any or all of them shall have been modified or cancelled in writing as a whole or in part.

A) All instructions and orders to CONTRACTOR shall, excepting what is herein provided, be given by OWNER/ CONSULTANT.

B) All the work shall be carried out under the direction of OWNER and according to the CONTRACT requirements.

C) All communications including technical / commercial clarifications and / or comments shall bear reference to the CONTRACT.

D) Invoice for payment against CONTRACT shall be addressed to OWNER.

E) The CONTRACT/DLOA number shall be shown on all invoices, communications, packing lists, containers and bills of lading etc.

15.0 INSPECTION, TESTING AND EXPEDITING

15.1 The OWNER or his representatives shall have their right to inspect and/or to test the goods to conform to the specifications laid down in the CONTRACT. The SPECIAL CONDITIONS OF CONTRACT and/ or the TECHNICAL SPECIFICATIONS shall specify what inspections and test the OWNER require and where they are to be conducted. The OWNER shall notify the CONTRACTOR in writing of the identity of any other representatives retained for this purpose. Expediting by OWNER's representative in no way relieves the CONTRACTOR of his obligation under the terms and conditions of this CONTRACT.

15.2 The inspections and tests may be conducted on the premises of the CONTRACTOR or his SUB-CONTRACTOR at point of completion and/or at the good's final destination. When conducted on the premises of the CONTRACTOR or his SUBCONTRACTOR, all reasonable facilities and assistances including access to drawings and production data shall be furnished to the inspector at no charge to the OWNER.

15.3 CONTRACTOR shall be held responsible for any possible delay in the approval or testing phase as well as for any possible delay in the remittance of necessary certificates. Delay on the part of the Inspection institutions will not be considered a case of 'Force Majeure'.

15.4 Participation or presence of OWNER or their representatives at any tests or their failure to be present at or to witness any tests to be undertaken pursuant here to shall not in any way or manner relieve or release the CONTRACTOR from any of its warranties, guarantees or other obligations under the CONTRACT.
15.5 Copies of all test results/report of the tests shall be furnished promptly by the CONTRACTOR to the OWNER.

16.0 TIME SCHEDULE AND PROGRESS REPORTING

16.1 Time Schedule Network/Bar Chart

16.1.1 Together with the CONTRACT confirmation, CONTRACTOR shall submit to OWNER, his time schedule regarding the documentation, supply and manufacture of equipment and materials as well as information of his SUBCONTRACTS to be placed with third parties, including the dates on which CONTRACTOR intends to issue such SUB CONTRACTS. A complete activity-wise time schedule shall be furnished by the CONTRACTOR within 30 days from the date of issuance of FOA.

16.1.2 The time schedule will be in the form of a network or a bar chart clearly indicating all main or key events regarding documentation, supply of raw materials, manufacturing, testing, delivery, erection & commissioning.

16.1.3 The original issue and subsequent revisions of CONTRACTOR's time schedule and/or SUB-CONTRACTORS' time schedules shall be sent in two copies to OWNER.

16.1.4 The time schedule network/bar chart shall be updated at least every month using the latest ‘Project Management software’, i.e. Primavera (latest version), acceptable to the OWNER.

16.2 PROGRESS TREND CHART/MONTHLY REPORT

16.2.1 CONTRACTOR shall report fortnightly to OWNER, the progress of the execution of CONTRACT and achievement of targets set out in time bar chart.

16.2.2 The progress will be expressed in percentages shown in the progress trend chart.

16.2.3 The first issue of the progress trend chart will be forwarded together with the time bar chart along with CONTRACT confirmation.

16.2.4 The monthly reporting will bear the updating of the progress trend chart.

16.2.5 OWNER or his representatives shall have the right to inspect CONTRACTOR's premises to evaluate the actual progress of work on the basis of CONTRACTOR's time schedule documentation.

16.2.6 Irrespective of such inspection, CONTRACTOR shall advise OWNER at the earliest possible date of any anticipated delay in the programme indicating the reasons thereof and corrective measures proposed thereto.

16.2.7 The time for completion and phased time schedule shall be subject to and in accordance with the provision of Sub-Clauses 16.2.8 and 16.2.9 below.

16.2.8 Neither OWNER nor CONTRACTOR shall be considered in default in performance of their obligations if such performance is prevented or delayed by FORCE MAJEURE conditions as stated in Clause 35.0.

16.2.9 Should the CONTRACTOR's preparation for the commencement of the work or any portion of it or its subsequent rate of progress be from any cause whatsoever, so slow and reasons for delay solely attributed to the contractor, the CONTRACTOR will not be able to complete the work or any portion thereof within the stipulated time for completion, the provisions of Clause 34 of GCC shall apply.
17.0 CONTRACTOR TO INFORM HIMSELF FULLY

The CONTRACTOR in fixing his rate shall for all purpose whatsoever reason may be, deemed to have himself independently obtained all necessary information for the purpose of preparing his tender and his tender as accepted shall be deemed to have taken into account all contingencies as may arise due to such information or lack of same. The correctness of the details, given in the Tender Document to help the CONTRACTOR to make up the tender is not guaranteed.

The CONTRACTOR shall be deemed to have examined the CONTRACT DOCUMENTS, to have generally obtained his own information in all matters whatsoever that might affect the carrying out of the works at the schedules rates and to have satisfied himself to the sufficiency of his tender. Any error in description of quantity or omission there from shall not vitiate the CONTRACT or release the CONTRACTOR from executing the work comprised in the CONTRACT according to DRAWINGS and SPECIFICATIONS at the scheduled rates. He is deemed to have known the scope, nature and magnitude of the WORKS and the requirements of materials and labour involved etc., and as to what all works he has to complete in accordance with the CONTRACT documents whatever be the defects, omissions or errors that may be found in the DOCUMENTS. The CONTRACTOR shall be deemed to have visited surroundings, to have satisfied himself to the nature of all existing structures, if any, and also as to the nature and the conditions of the Railways, Roads, Bridges and Culverts, means of transport and communication, whether by land, water or air, and as to possible interruptions thereto and the access and egress from the site, to have made enquiries, examined and satisfied himself as to the sites for obtaining sand, stones, bricks and other materials, the sites for disposal of surplus materials, the available accommodation as to whatever required, depots and such other buildings as may be necessary for executing and completing the works, to have made local independent enquiries as to the sub-soil, subsoil water and variations thereof, storms, prevailing winds, climatic conditions and all other similar matters effecting these works. He is deemed to have acquainted himself as to his liability of payment of Government Taxes, Customs duty and other charges, levies etc.

Any neglect or omission or failure on the part of the CONTRACTOR in obtaining necessary and reliable information upon the foregoing or any other matters affecting the CONTRACT shall not relieve him from any risks or liabilities or the entire responsibility from completion of the works at the scheduled rates and times in strict accordance with the CONTRACT.

It is, therefore, expected that should the CONTRACTOR have any doubt as to the meaning of any portion of the CONTRACT DOCUMENT he shall set forth the particulars thereof in writing to OWNER in duplicate, before submission of tender. The OWNER may provide such clarification as may be necessary in writing to CONTRACT, such clarifications as provided by OWNER shall form part of CONTRACT DOCUMENTS.

No verbal agreement or inference from conversation with any effect or employee of the OWNER before, during or after the execution of the CONTRACT agreement shall in any way affect or modify and of the terms or obligations herein contained.
Any change in layout due to site conditions or technological requirement shall be binding on the CONTRACTOR and no extra claim on this account shall be entertained.

18.0 **SUITABILITY OF PLANT FOR INTENDED PURPOSE**

18.1 The CONTRACTOR warrants that the PLANT will be suitable in all respects for the purpose mentioned or inherent in the specification and as defined in the CONTRACT.

18.2 Without limiting the generality of the foregoing clause, the CONTRACTOR shall ensure before complying with any direction, that compliance by the CONTRACTOR with that direction will not render the plant unsuitable in any respect for the aforesaid purposes or otherwise prevent the CONTRACTOR from carrying out the CONTRACT in accordance with the terms thereof.

18.3 The CONTRACTOR shall give notice to the OWNER within Twenty one (21) days after receipt of any requirement or direction which he considers will render the plant unsuitable in any respect or is not in accordance with the meaning and intent of the CONTRACT otherwise prevent the CONTRACTOR from carrying out the CONTRACT or as aforesaid and submit to the OWNER a proposal or proposals for modifying the requirement or direction. Failure to file an objection within the allotted time will be considered as acceptance of the OWNER decision and the decision shall become final and binding.

19.0 **FEES FOR ROYALTIES AND PATENT RIGHTS**

19.1 **Payment Due to be Included in CONTRACT PRICE**

19.1.1 All payments for royalties, patent rights and fees due to or payable for or in connection with any matter or thing used or required to be used in performance of the CONTRACT or to be supplied under the CONTRACT, whether payable in one sum or by instalments or otherwise, shall be included by the CONTRACTOR in the prices named in the CONTRACT and shall be paid by CONTRACTOR to whom such payments may be due or payable.

19.1.2 The CONTRACTOR, if licensed under any patent covering equipment, machinery, materials or compositions of matter to be used or supplied or methods and process to be practiced or employed in the performance of this CONTRACT, agrees to pay all royalties and license fees which may be due with respect thereto. If any equipment, machinery, materials, composition of matters, be used or supplied or methods and processes to be practiced or employed in the performance of this CONTRACT, is covered by a patent under which the CONTRACTOR is not licensed then the CONTRACTOR before supplying or using the equipment, machinery materials, composition method or processes shall obtain such licenses and pay such royalties and license fees as may be necessary for performance of this CONTRACT. In the event the CONTRACTOR fails to pay any such royalty or obtain any such license, any suit for infringement of such patents which is brought against the CONTRACTOR or the OWNER as a result such failure will be defended by the CONTRACTOR at his own expense and the CONTRACTOR will pay any damages and costs awarded in such suit.
The CONTRACTOR shall promptly notify the OWNER if the CONTRACTOR has acquired the knowledge of any plant under which a suit for infringement could be reasonably brought because of the use by the OWNER of any equipment, machinery, materials, process, methods to be supplied hereunder. The CONTRACTOR agrees to and does hereby grant to OWNER, together with the right to extend the same to any of the subsidiaries of the OWNER as irrevocable, royalty free license to use in any country, any invention made by the CONTRACTOR or his employee in or as result of the performance of the WORK under the CONTRACT.

19.2 Payment to the CONTRACTOR by OWNER

19.2.1 Final payment to the CONTRACTOR by the OWNER will not be made while any such suit or claim remains unsettled. In the event any apparatus or equipment or any part thereof furnished by the CONTRACTOR is in such suit or proceedings, held to constitute infringement, and its use is enjoined, the CONTRACTOR shall, at his option, and at his own expense, either procure for the OWNER the right to continue use of the said apparatus, equipment or part thereof, replace it with non-infringing apparatus or equipment or modify it, so that it becomes non-infringing.

20.0 ACTS OF PARLIAMENT, LOCAL AND OTHER AUTHORITIES REGULATIONS AND BYE-LAWS

20.1 Complying With Regulations

20.1.1 Throughout the execution of the WORK, the CONTRACTOR shall comply with the requirements of all applicable laws and regulations, bye-laws or orders made there under and to the requirements of public, municipal and other authorities in any way affecting or applicable to the work. The OWNER shall, when requested by the CONTRACTOR, give all reasonable assistance to the CONTRACTOR in obtaining information concerning local conditions.

20.1.2 Before making any departure from the specification or drawings which may be necessary to conform to such requirements, the CONTRACTOR shall give the OWNER written notice specifying the departure proposed to be made and the reason for making it and applying for instructions thereon. If the CONTRACTOR does not receive such instructions within thirty (30) days, he shall conform to those requirements and inform the OWNER accordingly.

20.2 Notices and Fees

The CONTRACTOR shall give all notices required to be given by the Acts, regulations, bye-laws, orders and requirements referred to in sub-clause 20.1 of this clause and shall pay all fees payable in connection herewith.

Any additional fee becoming applicable due to any change of Acts, regulations, by-laws, orders and requirements after date of submission of FINAL PROPOSAL shall be borne by OWNER in accordance with SCC clause 3.0.
21.0 TIME- PROJECT SCHEDULE

21.1 Without prejudice to anything contained in the CONTRACT, the time and the date of completion of the works as stipulated in the CONTRACT shall be deemed to be of the utmost importance. The CONTRACTOR shall so organise his resources and perform his work so as to complete it within the completion period.

21.2 The contractor shall submit the Primavera Level 4 schedule within thirty (30) days from date of issuance of FOA.

The Primavera Level 4 schedule shall be for OWNER’s review and be based on a level 2 schedule as attachment to the CONTRACT. Such level 2 schedule shall show the execution periods for (i) engineering, (ii) procurement & delivery of equipment and materials, (iii) civil & erection (iv) Mechanical Completion and (v) commissioning, testing.

Bidder shall be contractually obliged to issue a Primavera Level 4 schedule provided that such schedule shall not (i) accelerate the OWNER obligations (to be agreed upon prior to Contract award) (ii) change the GUARANTEED COMPLETION DATE.

21.3 The above Primavera Level 4 schedule shall be periodically reviewed and reports shall be submitted by the CONTRACTOR as directed by the OWNER.

22.0 CONTRACT PRICE

22.1 CONTRACT PRICE is inclusive of the cost/fees of CONTRACTOR’s obligations as given below briefly but not limited to the following:

a. Detailed Engineering
b. Basic Engineering
c. Supply of all Plant, Equipment, Bulk Materials, Chemicals & Lubricants and consumables
d. 6 months supervisory assistance
e. Supply of spares and consumables, lubricants, chemicals for commissioning
f. all applicable taxes and duties under GST, Indian Income Tax, etc.
g. Civil and Structural works,
h. Forwarding charges, if applicable,
i. Freight up to SITE including taxes,
j. Unloading, storage at Site, Site Assembly, Erection, Pre-Commissioning and Commissioning until Preliminary Acceptance of Plant.
k. Insurance
l. All taxes as applicable in India and outside India for execution of work under CONTRACT.
m. Inspection and expediting charges
n. Project management and overheads,
o. Guarantee test runs and handing over of PLANT to OWNER.

p. All other costs, expenses and outgoings of the CONTRACTOR not otherwise expressly set forth herein necessary, required or incidental to the full, complete and proper performance and discharge of the CONTRACTOR’s obligations under and in accordance with the CONTRACT including completion of the PLANT in all respects and overheads of the CONTRACTOR.

22.2 OWNER shall pay to CONTRACTOR a lump-sum fixed CONTRACT PRICE, for the due and faithful performance of CONTRACTOR's obligations under the CONTRACT. CONTRACT PRICE provided for in this Clause covers entire consideration payable to CONTRACTOR for all obligations of CONTRACTOR.

22.3 CONTRACT PRICE is inclusive of cost of all travel, accommodation, living costs and all other expenses of management and personnel of CONTRACTOR, SUB-CONTRACTOR, VENDOR and their agents for travelling to and from plant SITE and other places/countries as may be necessary for the proper performance of CONTRACTOR's responsibilities under CONTRACT and shall also include all costs and expenses incurred in attending such meetings in connection with CONTRACT as OWNER may reasonably require.

22.4 CONTRACT PRICE is inclusive of cost of all CONTRACTOR’s EQUIPMENT, materials, services, etc. required to complete WORK under CONTRACT.

22.5 Deleted

22.6 All taxes, duties, licence fees and other such levies as may be applied to the CONTRACT both in CONTRACTOR's country and in India, including Custom Duty, all applicable taxes & duties under GST. Corporate income tax in respect of the performance of the CONTRACT as well as income tax on the personnel deputed by the CONTRACTOR to India in connection with the CONTRACT shall be to the account of the CONTRACTOR.

23.0 DEDUCTIONS FROM CONTRACT PRICE

All costs, damages or expenses which the OWNER may have paid for which, under the CONTRACT, the CONTRACTOR is liable, will be claimed by the OWNER. All such claims shall be billed by the OWNER to the CONTRACTOR regularly as and when they fall due. Such claims shall be paid by the CONTRACTOR within fifteen days of the receipt of the corresponding bills and if not paid by the CONTRACTOR within the said period, the OWNER may then deduct the amount from any bill due or becoming due by him to the CONTRACTOR under the CONTRACT or may be recovered by action of law or otherwise, if the CONTRACTOR fails to satisfy the OWNER of such claims.

24.0 Deleted
25.0 PAYMENT TERMS

25.1 The payment to CONTRACTOR for the performance of the WORKS under the CONTRACT will be made by OWNER as per the guidelines & conditions specified in Section V i.e. SPECIAL CONDITIONS OF CONTRACT.

25.2 Schedule of Payment

The CONTRACTOR shall submit billing schedule which is to be approved by the OWNER. The CONTRACTOR shall submit all invoices for a particular month under a single covering letter (once in a month) based on the billing schedule duly certified by OWNER with related documents.

25.3 Due Date for Payment

OWNER will make progressive payments as and when the payment becomes due as per the terms of payment set forth in the CONTRACT. Payment will become due and payable by OWNER within 30 days, except Final Payment, from the date of receipt of CONTRACTOR'S bill/invoice by OWNER provided the documents submitted are complete in all aspects and are submitted as per billing schedule.

25.4 Payment Methodology

Bidder shall enclose all documents as per check list issued by PMC/OWNER. After receipt of complete RA Bill as per terms and conditions of the contract and duly certified by Engineer-in-Charge (EIC) / PMC, on-account payment equivalent to seventy percent (70%) of the net payable certified amount of the RA Bill will be released to the Contractor within a period of seven (07) working days from submission of certified bill by PMC to TFL. The balance amount will be released within a period of 15 days from submission of certified bill by PMC to TFL.

26.0 TAXES APPLICABLE TO CONTRACTOR’S MANPOWER, TURNOVER, EQUIPMENT, ETC.

26.1 The CONTRACTOR shall be liable and pay all taxes, duties, levies, lawfully assessed against the OWNER or the CONTRACTOR in pursuance of the CONTRACT. The CONTRACTOR shall be solely responsible for all taxes that may be levied on the CONTRACTOR's turnover & profit or on the earnings of any of his employees or personnel engaged by him and shall hold the OWNER indemnified and harmless against any claims that may be made against the OWNER in this behalf. The OWNER does not undertake any responsibility whatsoever regarding any taxes levied on CONTRACTOR and/or his personnel by Centre/State/Local Authorities. The Taxes shall be deducted where the said provisions shall be applicable and/or obligatory on the part of the OWNER.

26.2 For CONTRACTORS who have to bring equipment and material from outside Odisha, will have to obtain necessary registrations and take appropriate steps as required under Odisha State Laws. Further, form 38 / E-Waybill / Road Permit shall be issued by the CONTRACTOR in such cases, wherever applicable. Necessary statutory registrations as required shall be done by CONTRACTOR in this regard.

26.3 CONTRACTOR is responsible for obtaining Customs clearance permit for temporary importation on re-export basis of CONTRACTOR’S EQUIPMENT, tools and tackles etc. If any duties, taxes and expenses are payable on this, the same will be to CONTRACTOR'S account.
27.0 PACKING, FORWARDING AND SHIPMENT

27.1 The CONTRACTOR shall give complete despatch information concerning the weight, size, content of each package including any other information the OWNER may require.

27.2 The CONTRACTOR, wherever applicable shall after proper painting, pack and crate all equipment in such a manner as to protect it from deterioration and damage during rail and road transportation to the site and storage at the site till the time of erection. The CONTRACTOR shall be held responsible for all damages due to improper packing.

27.3 The CONTRACTOR shall notify the OWNER of the date of each shipment from his works, and the expected date for arrival at the site for the information of the OWNER. The CONTRACTOR will be responsible for arranging any requirement of over-dimensional, special rail/road wagon/trailer for transporting.

27.4 The CONTRACTOR shall also give all shipping information concerning the weight, size and content of each package including any other information the OWNER may require. The size of the largest packages being considered as over dimensional consignments shall be as per the latest guidelines.

27.5 The CONTRACTOR shall prepare detailed packing lists of all packages and containers, bundles and loose materials forming each and every consignment despatched to the site. The CONTRACTOR shall further be responsible for making all necessary arrangements for loading, unloading and other handling, right from works till the SITE and also till the EQUIPMENT is erected, tested and commissioned. The CONTRACTOR shall be solely responsible for proper storage and preservation of all equipments & machineries etc.

28.0 INSURANCE

28.1 CONTRACTOR shall take in the joint name of CONTRACTOR and OWNER comprehensive transit insurance for imported and indigenous goods. Transit-cum-Storage-Erection insurance or its equivalents and third party liability insurance policies shall be taken with reputed underwriters to cover ALL RISK whatsoever during the whole period starting with dispatch of GOODS from CONTRACTOR’s warehouses/ Ex works in foreign country to CIF port of shipment for imported GOODS and EXW at Contractor’s works for indigenous GOODS and shall further cover for performing services in India for transportation, loading, unloading, assembly, erection, testing COMMISSIONING of PLANT till care and custody is transferred to OWNER.

28.1.1 Contractor shall take Public Liability (Third Party) Insurance cover of 10% of TOTAL CONTRACT PRICE.

28.1.2 Contractor shall ensure that in addition to “Erection All risk policy”, the coverage in respect of workmen compensation, ESI/Health Insurance, Professional Indemnity (with the amount of minimum excess) has been appropriately taken.
28.2 CONTRACTOR shall be fully responsible for pursuing and settling all claims under the underwriters. In the event of accident, injury, damage or loss likely to form a claim under the above insurance policies, CONTRACTOR shall, as quickly as possible submit the insurance claims by underwriters under intimation to OWNER. CONTRACTOR shall also keep OWNER fully informed about progress of each such case. CONTRACTOR shall undertake immediate repair and replacement of the equipment lost in transit, storage, assembly, erection and COMMISSIONING of PLANT pending settlement of claim thereafter by the underwriters.

28.3 The CONTRACTOR at his cost shall arrange, secure and maintain all insurance as may be pertinent to the works and obligatory in terms of law to protect his interest and interest of OWNER in the project, against all perils detailed herein. The Form and the limit of such insurance as defined herein together with the under-writer in each case shall be acceptable to the OWNER and OWNER’s acceptance shall not be unreasonably withheld. However, irrespective of such acceptance, the responsibility to maintain adequate insurance coverage at all times including third party liability during the period of contract shall be as of CONTRACTOR alone. The contractor’s failure in this regard shall not relieve him of any of his contractual responsibilities and obligations. The insurance covers to be taken by the CONTRACTOR shall be in the joint names of OWNER and the CONTRACTOR. The CONTRACTOR shall, however, be authorised to deal directly with insurance company or companies and shall be responsible in regard to maintenance of all insurance covers.

28.4 All insurance other than marine insurance for transportation outside India is to be covered from IRDA approved insurance company registered in India. There should be a single cover for marine cum inland transit, storage and erection up to PRELIMINARY ACCEPTANCE OF PLANT.

However adequacy, credibility and maintenance of Insurance policies is sole responsibility of CONTRACTOR and CONTRACTOR shall keep the OWNER indemnified against any such failure.

All insurance covers shall be taken by CONTRACTOR in joint name of CONTRACTOR and OWNER.

Alternatively, the CONTRACTOR has the option to take separate Insurances as

1. Marine Cargo Insurance for transit of all imported and indigenous goods from Ex-Works at CONTRACTOR’S/ SUB-CONTRACTOR’s works to Site.
2. Erection and All Risk (EAR) Insurance
3. Third Party Liability Insurance

Marine Cargo Insurance and Third Party Liability Insurance can be a part of Global Policy of the CONTRACTOR. However certificate of endorsement in favour of OWNER shall be provided by the CONTRACTOR from the insurance company. These two global policies of Marine Cargo Insurance and Third Party Liability Insurance shall be counter guaranteed by Indian Insurance Company. However, Erection and All Risk (EAR) is to be covered from Insurance Company registered in India and shall be separate dedicated policies for OWNER.

28.5 Any loss or damage to the equipment during handling, transportation, storage, erection, putting the equipment into satisfactory operation and all activities to be performed till the
successful completion of trial operation of the plant shall be to the account of the CONTRACTOR. The CONTRACTOR shall be responsible for reference of all claims and make good the damages or loss by way of repairs and/or replacement of the equipment, damaged or lost. The CONTRACTOR shall provide the OWNER with copies of all insurance policies and documents taken out by him in pursuance of the CONTRACT. Such copies of documents shall be submitted to the OWNER immediately after such insurance coverage. However, if Marine cargo insurance or Third party liability Insurance is a part of their global policies; insurer certificate (including the main terms of policy) shall be submitted by CONTRACTOR. The CONTRACTOR shall also inform the OWNER in the writing at least thirty (30) days in advance regarding the expiry/cancellation and/or change in any of such documents and ensure revalidation, renewal etc. as may be necessary well in time. However adequacy, credibility and maintenance of Insurance policies is the sole responsibility of CONTRACTOR and CONTRACTOR shall keep the OWNER indemnified against any such failure.

28.6 The perils required to be covered under the insurance shall include, but not be limited to fire and allied risks, miscellaneous accidents (erection risks) workman compensation risks, loss or damage in transit, theft, pilferage, riot and strikes and malicious damages, civil commotion, weather conditions, accidents of all kinds, war risks (during ocean transportation only) etc. The scope of such insurance shall be adequate to cover the replacement/reinstatement cost of the equipment for all risks till the equipment is taken over by the OWNER. The insurance policies to be taken should be on replacement value basis and/or incorporating escalation clause. Notwithstanding the extent of insurance cover and the amount of claim available from the underwriters, the CONTRACTOR shall be liable to make good the full replacement/rectification of all equipment/materials and to ensure their availability as per project requirements without additional financial liability to the OWNER.

The workman compensation policy taken by the SUB-CONTRACTOR of the CONTRACTOR shall be passed on to the OWNER.

28.7 CONTRACTOR shall at its own cost and initiative at all times upto the successful completion of PRELIMINARY ACCEPTANCE, take out and maintain all insurable liability, including but not limited to third Party insurance and liabilities under the Motor Vehicles Act, Worker’s Compensation Act, Fatal Accidents Act, Personal Injuries Insurance Act, Emergency Risk Insurance Act and/or other Industrial Legislation from time to time in force in India with Insurance Company(ies), such policy(ies) shall not be of lesser limits hereunder specified with reference to the matters hereunder specified, namely:

- Workmen’s Compensation Insurance to the limit to which compensation may be payable under Indian laws.

28.8 All cost on account of insurance liabilities covered under the CONTRACT will be to the CONTRACTOR’S account and will be included in the CONTRACT PRICE. The CONTRACTOR, while arranging the insurance, shall ensure to obtain all discounts on premium, which may be available for higher volume or for reason of financing arrangement of the project.

28.9 Irrespective of single or separate insurances, the CONTRACTOR shall take the same in the joint name of OWNER and CONTRACTOR, with OWNER as Primary Beneficiary and
CONTRACTOR as Joint Beneficiary, to cover all risk including marine cum erection insurance (MCE), workmen compensation / Employees State Insurance (ESI) under ESI Act 1948 for Contractor's personnel, fire risk policy etc. till handing over of PLANT to OWNER duly commissioned and tested. However, for CONTRACTOR’s EQUIPMENT, CONTRACTOR can be the sole beneficiary.

Further, OWNER shall have the first right over the claim amount for all insurance claims, where owner has made part or full payment to the contractor.

However, OWNER should have first right over the claim amount in case payment for the “equipment damaged” has already been paid to the CONTRACTOR

28.10 The CONTRACTOR shall be fully responsible for pursuing and settling all claims with the underwriters. In the event of accident, injury, damage or loss likely to form a claim under the above insurance policies, the CONTRACTOR shall as quickly as possible but not later than the claim period submit such details as are necessary for settling such claims by underwriters and shall also provide information and assistance necessary to settle the claim. The CONTRACTOR shall also keep OWNER fully informed about progress of each such case.

28.11 The charges quoted on account of insurance in the price bid shall be considered for the purpose of evaluation. However if owner opts to take policy, the contract price shall be adjusted to the extent of cost of insurance quoted in the price bid.

29.0 GUARANTEES

29.1 It shall be a condition of the CONTRACT and the CONTRACTOR shall guarantee that the plant shall achieve the requirement as set forth herein and as per the provisions of the Section VI-8.0 of Technical NIT.

29.2 The CONTRACTOR shall guarantee that the Plants, Equipment and machineries will be new and in accordance with the CONTRACT documents and free from defects in design, material and workmanship and shall give mechanical warranty for a period of Twelve (12) calendar months commencing immediately upon PRELIMINARY ACCEPTANCE as per Clause 17 SCC. The CONTRACTOR's liability shall be limited to the replacement of any defective parts in the equipment of his own manufacture or those of his SUB-CONTRACTOR under normal use and arising from faulty design, materials and/or workmanship provided always that such defective parts are not repairable at the site and are not in the meantime essential in the commercial use of the plant. Such replaced defective parts shall be returned to the CONTRACTOR unless otherwise arranged.

29.3 After the issue of the PRELIMINARY ACCEPTANCE CERTIFICATE, in the event of an emergency where, in the judgement of the OWNER, delay would cause serious loss or damage, repairs or adjustments may be made by the OWNER or a third party chosen by the OWNER without advance notice to the CONTRACTOR and the documented and direct cost of such work shall be paid by the CONTRACTOR but only to the extent that the repair or adjustment was due a defect attributable to CONTRACTOR.

29.4 Deleted.
29.5 Deleted.

29.6 The cost of any special or general overhaul rendered necessary during the guarantee period due to defects for which CONTRACTOR is liable under CONTRACT in the PLANT or defective work carried out by the CONTRACTOR shall be borne by the CONTRACTOR.

29.7 The acceptance of any equipment by the OWNER shall in no way relieve the CONTRACTOR of his obligation under this clause.

29.8 In the case of those defective parts which are not repairable at site but are essential for the commercial use of the equipment and machineries, the CONTRACTOR shall mutually agree to a programme of replacement or renewal which will minimise interruption to the maximum extent, in the operation of the equipment and machineries.

29.9 At the end of the DEFECT LIABILITY PERIOD or the extended DEFECT LIABILITY PERIOD, the CONTRACTOR's liability ceases. In respect of goods supplied by the SUB-CONTRACTORS to the CONTRACTOR where a long guarantee (more than 12 months) is provided by such SUBCONTRACTORS/SUB- VENDOR(s), the OWNER shall be entitled to the benefit of such longer guarantees.

29.10 During the GUARANTEE PERIOD, the CONTRACTOR shall provide if required by the OWNER, the services of operation engineers to advise the OWNER for such period and in such number as may be mutually agreed upon. The CONTRACTOR's operation engineers shall also train the OWNER's personnel, act as a liaison between the OWNER and the CONTRACTOR, assist the OWNER in ordering and obtaining spare parts, generally monitoring operation and maintenance and trouble shooting and supervising repair work under guarantee.

29.11 The provisions of Clause 48.0 of GCC including the cost of transport, insurance etc. shall be implemented at the CONTRACTOR's expenses.

29.12 The provisions contained in clause 48 of GCC will not be applicable if after handing over of the PLANT, the OWNER has not operated the equipment according to generally followed industrial practices and in accordance with the conditions of operation specified in accordance with operation and maintenance manuals.

29.13 Guarantees for Time of Completion

The CONTRACTOR shall guarantee the date of PRELIMINARY ACCEPTANCE of the WORK calculated from the date of issuance of FOA, for the purpose of determining predetermined MUTUALLY AGREED DAMAGES on account of delay in completion.

29.14 Performance Guarantees

CONTRACTOR shall guarantee the performance of PLANTS as well as works cost guarantee as specified in the Technical Documents. In general the Guarantees shall be demonstrated as per Section VI-8.0 of NIT.

29.15 Design and Vendors'/ Sub-Contractors' Guarantees
29.15.1 CONTRACTOR shall guarantee the design and engineering work carried out by him against mistakes, errors, defective specifications, inadequacy and other such items which lead to the supply of inadequate PLANTS and Facilities. In case of detection of such mistakes, errors, deficiencies etc. the CONTRACTOR shall redo the design and/or engineering work to overcome all such mistakes, errors, deficiencies etc. at no extra cost to OWNER.

29.15.2 CONTRACTOR shall be responsible for all the items of the EQUIPMENT procured by him from VENDORS/ SUB-CONTRACTORS. Further, CONTRACTOR shall replace or repair any item of EQUIPMENT which is demonstrated to be defective under normal operating conditions within DEFECT LIABILITY PERIOD.

30.0 LIABILITY FOR ACCIDENTS AND DAMAGES

30.1 Under the CONTRACT, the CONTRACTOR shall be responsible for loss or damage to the PLANT and provide new equipment and machineries in lieu of equipment/machineries lost/damaged beyond repairs, free of cost until the PLANT is handed over after successful completion of performance guarantee test run.

Notwithstanding the provisions in the CONTRACT, the CONTRACTOR shall not be responsible for any loss or damage to the PLANT or any part thereof if and to the extent that such loss or damage is not covered by insurance coverage such as War risk, provided the same is general exclusion of the policy of the EAR insurance. War Risks shall mean any of the following events occurring within India: War, hostilities, warlike operations (whether a state of war be declared or not), invasion, act of foreign enemy, civil war, rebellion, terrorism, revolution, insurrection, mutiny, usurpation of civil or military government, conspiracy, riot, civil commotion, mine, bomb, shell, grenade or other projectile, missile, munitions or explosive of war.

30.2 The CONTRACTOR shall indemnify the OWNER in respect of all damage or injury to any person or to any property (other than property forming part of the Work) and against all actions, suits, claims, demands, costs, charges and expenses arising in connection therewith which shall have been occasioned by the negligence of the CONTRACTOR or any SUB-CONTRACTOR, or by defective design (other than a design made, furnished or specified by the OWNER and which the CONTRACTOR has disclaimed responsibility in writing within a reasonable time after receipt of the OWNER's instructions) material or workmanship, any breach of the CONTRACTOR's obligations.

31.0 MUTUALLY AGREED DAMAGES (MAD)

31.1 For Delay in Completion

31.1.1 The CONTRACTOR agrees that the work shall be commenced and carried on at such points, and in the order of precedence and at such times and seasons as may be directed by the OWNER in accordance with the schedule for the completion of work as outlined in the CONTRACT. The CONTRACTOR declares that he has familiarised himself with the site and rights of way, ground conditions, with all the local conditions, and with all the circumstances which may or are likely to affect the performance and completion of the work and that he has allowed for such conditions in the preparation of this schedule. The progress of work shall be checked at regular monthly intervals and the percentage
progress achieved shall be commensurate with the time elapsed after the award of the CONTRACT.

31.1.2 However, it is not incumbent upon the ENGINEER-IN-CHARGE to notify the CONTRACTOR when to begin or to cease or to resume work, nor to give early notice of the rejection of a faulty work, nor in any way to superintend so as to relieve the CONTRACTOR of responsibility of any consequence of neglect or carelessness by him or his subordinates.

31.1.3 The time stipulated in the CONTRACT for the execution and completion of the works is shall be deemed to be of utmost importance of the CONTRACT. In the event the CONTRACTOR fails to attain the PRELIMINARY ACCEPTANCE within the GUARANTEED COMPLETION DATE due to the reasons for which CONTRACTOR is liable under CONTRACT then the CONTRACTOR shall pay to the OWNER as MAD at the rate of 0.5 % of the TOTAL CONTRACT PRICE (excluding taxes) per week of delay or part thereof subject to a maximum of 5% of the TOTAL CONTRACT PRICE (excluding taxes) . The OWNER may, without prejudice to any method of recovery, deduct the amount for such damages from any amount due or which may become due to the CONTRACTOR. In the event of extension of time being granted by the OWNER in writing for completion of the WORKS without levy of MAD (Mutually Agreed Damages), this clause will be applicable after expiry of such extended period. GST at the prevailing rate, if applicable on “MUTUALLY AGREED DAMAGES” shall be recovered extra from the CONTRACTOR on the amount of such MUTUALLY AGREED DAMAGES levied as per the Contractual terms.

OWNER shall raise separate Tax Invoice for recovery of MAD along with applicable GST.

Mutually Agreed Damages represent, without prejudice to the respect of the contractual obligation under the CONTRACT by CONTRACTOR, the sole and exclusive remedy of OWNER for such delay.

The decision of the OWNER on the applicability of MAD shall be final and binding on the CONTRACTOR.

31.1.4 Bonus for early completion

In the event, CONTRACTOR completes and delivers the WORKS and achieves PRELIMINARY ACCEPTANCE earlier than the time specified in the CONTRACT, then the CONTRACTOR shall be eligible for a bonus. The bonus shall be calculated @ 0.20% of the TOTAL CONTRACT PRICE (excluding taxes & duties) per completed week for earlier completion subject to a maximum of 1.0% of the TOTAL CONTRACT PRICE (excluding taxes & duties).

31.2 For Failing to Meet Works Cost Guarantee

LSTK bidder shall guarantee overall consumption/Generation of Raw Material and Utilities /Condensate for the production of Steam so as to guarantee the works cost for all the facilities provided by the CONTRACTOR as detailed in Technical Section VI-8.
In the event works cost is more than 100% but upto 102.5% of the Guaranteed Works Cost then the CONTRACTOR will pay Owner Mutually Agreed Damages as specified hereunder

For every 0.50% increase in Works cost above the guaranteed works cost or part thereof, CONTRACTOR will pay Mutually Agreed Damages equal to 1.0% of the TOTAL CONTRACT PRICE (excluding taxes).

If the Guaranteed Works cost as demonstrated during the performance test is more than 102.5% of the Guaranteed Works Cost, then CONTRACTOR at their own cost shall take corrective action irrespective of the cost involved. In case the Guaranteed Works Cost is more than 102.5% even after taking the corrective action, the same shall be considered as breach of Contract and necessary action as per clause 34 of GCC shall be taken by OWNER.

32.0 OVERALL CEILING ON TOTAL LIABILITY

32.1 The Maximum Overall Liability under the CONTRACT on account of (a) Delay in execution of project (b) Contractor failing to meet the Guaranteed Works Cost up to 102.5%, (c) Termination of CONTRACT (d) Carrying out balance work at the risk and cost of the CONTRACTOR, re-engineering, make good, mechanical warranty (e) Patent infringement and (f) any other liabilities (if any) defined in the NIT shall be capped to 100% of the TOTAL CONTRACT PRICE.

32.2 Except for criminal negligence or wilful misconduct, the Contractor shall not be liable to the Owner, whether in contract, tort, or otherwise, or any indirect or consequential loss or damage, loss of use, loss of production, or loss of profit or interest cost, provided that this exclusion shall not apply to any obligation of the Contactor to pay liabilities to the Owner, as defined in clause 32.1 above.

33.0 TIME EXTENSION OF CONTRACT

33.1 The CONTRACTOR shall promptly notify the ENGINEER-IN-CHARGE any event or conditions which might delay the completion of erection work in accordance with the approved schedule and the steps being taken to remedy such situation.

33.2 If the Work is delayed at any time in the commencement or during the progress of the WORK by any act, delay or neglect solely attributable to OWNER or his employees, or by any other contractor utilised by the OWNER or by FORCE MAJEURE conditions, the time of completion shall be extended by OWNER (without levy of Mutually Agreed Damages) in writing for a reasonable period as may be mutually agreed upon, at the time of closure of contract. The CONTRACTOR shall, immediately on occurrence of such special circumstances but not later than 14 working days, bring to the knowledge of OWNER through written application for any such delay as mentioned above.

33.3 OWNER shall have the right to suspend the WORK in whole or in part for such time as may be necessary in order that WORKS shall be well and properly executed. In such events, suitable extension of time shall be granted to CONTRACTOR. However, should the cumulative period of suspension exceed 45 days during the scheduled duration of CONTRACT, the CONTRACTOR shall be compensated as mutually agreed in addition
to extension of time, provided the suspension is caused due to reasons not attributable to CONTRACTOR.

### 34.0 TERMINATION OF CONTRACT

#### 34.1 Termination due to Legal Incapacity

If the CONTRACTOR goes into liquidation or has an administrator order made against him or carries on his business or any part of it under an administrator or receiver or manager for the benefit of the creditors or any of them, without prejudice to any other rights or remedies, the OWNER may forthwith by notice in writing terminate the CONTRACT.

#### 34.2 Termination due to Default by CONTRACTOR

##### 34.2.1 If the CONTRACTOR is in default in that he:

(a) Neglects to execute the work or part of the work; or

(b) without reasonable cause, suspends or abandons the carrying out the works, either partly or wholly, before their completion; or

(c) Fails to proceed regularly and diligently with the works; or

(d) Defaults in the performance or observance of any conditions or terms of the CONTRACT or neglects to carry out any order, instruction, direction or determination which the OWNER is empowered to give or make under the CONTRACT and which is given or made in writing to the CONTRACTOR,

then, without prejudice to any other rights or remedies which the OWNER may possess, the OWNER may, by notice in writing (which shall specify with reasonable particularity the neglect, default or refusal on the part of the CONTRACTOR) require the CONTRACTOR:

i) to put forward his proposals for

   a) Rectifying such neglect, default or refusal as the case may be and

   b) Commence and diligently pursue the rectification of the default.

##### 34.2.2 If within 30 days after the posting of the notice addressed to the CONTRACTOR, the CONTRACTOR fails to comply with the notice or if in the opinion of the OWNER, the CONTRACTOR's reasons or proposals are not satisfactory, then the OWNER, without prejudice to any other rights that he may have under the CONTRACT against the CONTRACTOR, may either:

a) DETERMINE THE CONTRACT in which event the CONTRACT shall stand terminated and shall cease to be in force and effect on and from the date appointed by the OWNER on that behalf, whereupon the CONTRACTOR shall stop forthwith any of the CONTRACTOR's work then in progress, except such WORK as the OWNER may, in writing, require to be done to safeguard any property or WORK, or installations from damage, and the OWNER, for its part, may take over the work
remaining unfinished by the CONTRACTOR and complete the same through a fresh contractor or by other means, at the risk and cost of the CONTRACTOR, and any of his sureties if any, shall be liable to the OWNER for any excess cost occasioned by such work having to be so taken over and completed by the OWNER over and above the cost at the rates specified in the schedule of quantities and rate/prices.

b) WITHOUT DETERMINING THE CONTRACT, take over the work of the CONTRACTOR or any part thereof and complete the same through a fresh contractor or by other means at the risk and cost of the CONTRACTOR. The CONTRACTOR and any of his sureties are liable to the OWNER for any excess cost over and above the cost at the rates specified in the Schedule of Quantities/ rates, occasioned by such works having been taken over and completed by the OWNER.

In such events of Clause 34.2.2 (a) or (b) above.

(i) The whole or part of the Contract Performance Security furnished by the CONTRACTOR is liable to be forfeited without prejudice to the right of the OWNER to recover from the CONTRACTOR the excess cost referred to in the sub-clause aforesaid, the OWNER shall also have the right of taking possession and utilising in completing the works or any part thereof, such as materials equipment and plants available at work site belonging to the CONTRACTOR as may be necessary and the CONTRACTOR shall not be entitled for any compensation for use or damage to such materials, equipment and plant.

(ii) The amount that may have become due to the CONTRACTOR on account of work already executed by him shall not be payable to him until after the expiry of Six (6) calendar months reckoned from the date of termination of CONTRACT or from the taking over of the WORK or part thereof by the OWNER as the case may be, during which period the responsibility for faulty materials or workmanship in respect of such work shall, under the CONTRACT, rest exclusively with the CONTRACTOR. This amount shall be subject to deduction of any amounts due from the CONTRACT to the OWNER under the terms of the CONTRACT authorised or required to be reserved or retained by the OWNER.

(iii) Before determining the CONTRACT as per Clause 34.2.2 (a) or (b) provided in the judgement of the OWNER, the default or defaults committed by the CONTRACTOR is/are curable and can be cured by the CONTRACTOR if an opportunity given to him, then the OWNER may issue Notice in writing calling the CONTRACTOR to cure the default within such time specified in the Notice.

(iv) The OWNER shall also have the right to proceed or take action as per 34.2.2 (a) or (b) above, in the event that the CONTRACTOR becomes bankrupt, insolvent, compounds with his creditors, assigns the CONTRACT in favour of his creditors or any other person or persons, or being a company or a corporation goes into voluntary liquidation, provided that in the said events it shall not be necessary for the OWNER to give any prior notice to the CONTRACTOR.

(v) Termination of the CONTRACT as provided for in sub-clause 34.2.2(a) above shall not prejudice or affect their rights of the OWNER which may have accrued up to the date of such termination.

34.2.3 In case of termination of CONTRACT herein set forth (under clause 34.2) except under conditions of Force Majeure and termination after expiry of contract, the
CONTRACTOR shall be put under holiday [i.e. neither any enquiry will be issued to the party by Talcher Fertilizers Limited (TFL) or any of it’s JV partners against any type of tender nor their offer will be considered by TFL or any of it’s JV partners against any ongoing tender (s) where contract between TFL/it’s JV partners and that particular CONTRACTOR (as a bidder) has not been finalized], for a period of three years from the date of termination by TFL to such CONTRACTOR.

34.3 Duration of suspension of payment due to CONTRACTOR:

34.3.1 Owner shall have right to suspend making any payments to the contractor for the portion of WORK having a bearing with CONTRACTOR's default during the period of rectification of the defaults.

34.4 Work taken out of the hands of the CONTRACTOR

34.4.1 Employment of other contractors:

If the OWNER takes action under sub-clause 34.2.2, he may complete the work or any part of it by contracting with or employing any other contractor to execute further and complete work or any part of it and to provide all equipment, materials and labour as may be necessary for such further execution and completion. If practicable the further execution and completion shall be carried out in accordance with the specification and at prices obtained under competitive conditions.

The OWNER may also take possession of and permit such person or persons to use for the purposes of the CONTRACT only such materials, tools and equipment and all other things on or about the SITE which are the property of the CONTRACTOR as are requisite and necessary for such further execution and completion, and the CONTRACTOR shall have no right to any compensation or allowance in respect thereof.

On the completion of such work, all tools and equipment and the surplus of the materials so taken possession of shall be handed over to the CONTRACTOR but without payment or allowance for the fair wear and tear they may have sustained in the meantime, provided that if there by a deficiency as referred to in sub clause 34.4.2 of this clause, and if the CONTRACTOR fails to make good such deficiency such of the tools, equipment and materials as are necessary to make good the deficiency may be sold and a sufficient part of the monies received retained by the OWNER and applied in payment of such deficiency.

In addition the OWNER shall be entitled:

a) To take possession of and remove from the CONTRACTOR's premises within a reasonable period anything (including but without limiting the generality thereof any design, drawings, specification, material or other goods) the property which is vested in the OWNER pursuant to the CONTRACT;

b) To full particulars of any sub-contract made by the CONTRACTOR with any person for the execution of any portion of the WORKS and to peruse and copy any instrument (including but without limiting the generality thereof any agreement, letter or other paper) relating to any such SUB-CONTRACT made by the CONTRACTOR with any person for the execution of any portion of the WORKS.
c) To pursue and copy any standard working drawing or other drawing or data necessary in the opinion of the OWNER for completion of the WORKS and the property which is not vested to the OWNER pursuant to the CONTRACT provided that the OWNER shall in no case make use of any copy made pursuant to sub paragraphs (b) or (c) hereof other than for the purpose of completing the WORKS and that on the fulfilment of the whole of the obligations of the CONTRACTOR under the CONTRACT the OWNER shall return to the CONTRACTOR any such copy.

The CONTRACTOR shall offer to the OWNER all rights of access and all reasonable facilities to enable the OWNER to remove any such thing or pursue or copy any such instrument, drawing or data and shall supply such particulars on request by the OWNER in that behalf.

For the purposes of sub-clause 34.4.2 the cost incurred by the OWNER in and about for such removal, perusal or copying or obtaining such particulars shall be deemed to be part of the cost of carrying out that portion of the work taken out of the CONTRACTOR's hands.

34.4.2 Extra cost to the OWNER of completing work for deduction:

On completing the terminated portion of WORK as provided under Article 34.4.1 the OWNER shall ascertain the reasonable and direct costs based on the documentary evidence of the cost incurred but such amount shall not include any extra cost due to departures from the specification unless such departures were necessitated by the CONTRACTOR's default. Should the amount so ascertained be greater than the CONTRACT PRICE which would have been paid to the CONTRACTOR, if the whole of the Work had been carried out by him, the difference between the two amounts shall be deducted from any monies which may then be or thereafter become due to the CONTRACTOR or which may have been deposited by him as security under the CONTRACT, and if such monies be less than the amounts to be deducted the deficiency shall be paid by the CONTRACTOR to the OWNER and which may be recovered as provided in subclause 34.4.1 of this clause or by way of arbitration, jurisdiction or both, such payment of excess amount shall be independent of penalty for delay if the completion of work is delayed.

34.5 Preservation of rights of the OWNER

No action taken by the OWNER under sub clause 34.3 and 34.4 of this clause shall vitiate the CONTRACT or shall operate to the prejudice of the right of the OWNER to recover from the CONTRACTOR or to deduct from any monies which may be or may become due to the CONTRACTOR all sums of money which may be or may become due to the OWNER under the CONTRACT as damages, penalties or otherwise.

34.6 Should the OWNER decide to terminate the CONTRACT under subclause 34.2.2(b) of this clause, he may do so under notice in writing as from the date of such notice, and the termination shall be without prejudice to any right that may have occurred to the OWNER or to the CONTRACTOR under the CONTRACT.
34.7 Termination of Contract on Account of OWNER's Convenience

34.7.1 The OWNER, may, by 30 days written notice send to the CONTRACTOR, terminate the CONTRACT, in whole or in part, at any time for his convenience. The notice of termination shall specify that termination is for the OWNER's convenience, the extent to which performance of work under the CONTRACT is terminated and the date upon which such termination becomes effective.

34.7.2 Upon receipt of the notice of termination under GCC Clause 34.7.1, the CONTRACTOR shall either immediately or upon the date specified in the notice of termination.

(a) cease all further work, except for such work as the OWNER may specify in the notice of termination for the sole purpose of protecting that part of the Facilities already executed, or any work required to leave the Site in a clean and safe condition.

(b) terminate all subcontracts, except those to be assigned to the OWNER pursuant to paragraph (d)(ii) below.

(c) remove all CONTRACTOR's Equipment from the Site, repatriate the CONTRACTOR's and its SUB-CONTRACTORs' personnel from the Site, remove from the Site any wreckage, rubbish and debris of any kind, and leave the whole of the Site in a clean and safe condition.

(d) In addition, the CONTRACTOR, subject to the payment specified in GCC Clause 34.7.2.1, shall

(i) deliver to the OWNER the parts of the PLANT executed by the CONTRACTOR up to the date of Termination.

(ii) to the extent legally possible, assign to the OWNER all right, title and benefit of the CONTRACTOR to the PLANT and Equipment as at the date of termination, and, as may be required by the OWNER, in any subcontracts concluded between the CONTRACTOR and its SUB-CONTRACTORs.

(iii) deliver to the OWNER all non-proprietary drawings, specifications and other documents prepared by the CONTRACTOR or its Sub-CONTRACTORs as at the date of termination in connection with the PLANT.

34.7.2.1 In the event of termination of the Contract under GCC Clause 34.7.1, the OWNER shall pay to the CONTRACTOR the following amounts:

(a) the Contract Price, properly attributable to the parts of the PLANT executed by the CONTRACTOR as of the date of termination

(b) the costs reasonably incurred by the CONTRACTOR in the removal of the CONTRACTOR's Equipment from the Site and in the repatriation of the CONTRACTOR's and its SUB-CONTRACTORs' personnel
(c) any amounts to be paid by the CONTRACTOR to its SUB-CONTRACTORs or Vendors in connection with the termination of any subcontracts or supply agreement, including any cancellation charges

(d) costs incurred by the CONTRACTOR in protecting the PLANT and leaving the Site in a clean and safe condition pursuant to paragraph (a) of GCC Clause 34.7.2

34.7.3 Termination for Insolvency

OWNER may at any time terminate CONTRACT giving written notice to CONTRACTOR, if CONTRACTOR becomes bankrupt or otherwise insolvent, provided that such termination will not prejudice or affect any right of action or remedy which has occurred or will accrue thereafter to OWNER.

If the Contract is terminated under GCC Sub-Clauses 34.7.3, the OWNER shall pay to the CONTRACTOR all payments specified in GCC Sub-Clause 34.7.2 as reasonable compensation for all loss or damage sustained by the CONTRACTOR arising out of, in connection with or in consequence of such termination.

34.7.4 Termination by CONTRACTOR due to default of OWNER

If the OWNER has failed to pay the CONTRACTOR any sum due under the Contract within the specified period or commits a substantial breach of the CONTRACT, the CONTRACTOR may give a notice to the OWNER that requires payment of such sum or specifies the breach and requires the OWNER to remedy the same, as the case may be. If the OWNER fails to pay such sum or fails to remedy the breach or take steps to remedy the breach within thirty (30) days after receipt of the CONTRACTOR’s notice then the CONTRACTOR may give a notice to the OWNER thereof, and if the OWNER has failed to pay the outstanding sum or to remedy the breach within thirty (30) days of such notice, the CONTRACTOR may by a further notice to the OWNER, terminate the CONTRACT.

If the CONTRACT is terminated under GCC Clause 34.7.4, the OWNER shall pay to the CONTRACTOR all payments specified in GCC Clause 34.7.2 as reasonable compensation for all loss or damage sustained by the CONTRACTOR arising out of, in connection with or in consequence of such termination.

34.8 Surviving Obligations

Termination of this CONTRACT (a) shall not relieve CONTRACTOR of its obligations with respect to the confidentiality as set forth in this CONTRACT, (b) shall not relieve CONTRACTOR of any obligation hereunder which expressly or by implication survives termination hereof, and (c) except as otherwise provided in any provision of this CONTRACT expressly limiting the liability of CONTRACTOR, shall not relieve CONTRACTOR of any obligations or liabilities for loss or damage to the other Party arising out of or caused by acts or omissions of CONTRACTOR prior to the effectiveness of such termination or arising out of such termination, and shall not relieve CONTRACTOR of its obligations as to portions of SERVICES already performed or of obligations assumed by CONTRACTOR prior to the date of termination, except as otherwise agreed by OWNER in writing.
Termination of this CONTRACT (a) shall not relieve OWNER of its obligations with respect to the confidentiality as set forth in this CONTRACT, (b) shall not relieve OWNER of any obligation hereunder which expressly or by implication survives termination hereof, and (c) shall not relieve OWNER of any obligations or liabilities for loss or damage to the other Party arising out of or caused by acts or omissions of OWNER prior to the effectiveness of such termination or arising out of such termination.

35.0  FORCE MAJEURE

35.1 CONDITIONS FOR FORCE MAJEURE: In the event of either party being rendered unable by Force Majeure to perform any obligations required to be performed by them under the CONTRACT the relative obligation of the party affected by such Force Majeures shall upon notification to the other party be suspended for the period during which Force Majeures conditions lasts. The cost and loss sustained by the either party shall be borne by the respective parties. The term "Force Majeures" as employed herein shall mean acts of God, earthquake, war (declared or undeclared), revolts, riots, fires, floods, rebellions, explosions, hurricane, sabotage, civil commotions and acts and regulations of respective Government of the two parties, namely the OWNER and the CONTRACTOR. Upon the occurrence of such cause(s) and upon its termination, the party alleging that it has been rendered unable as aforesaid thereby, shall notify the other party in writing immediately but not later than 120 (one hundred and twenty) hours of the alleged beginning and ending thereof giving full particulars and satisfactory evidence in support of its claim. Time for performance of the relative obligation suspended by the Force Majeure(s) shall then stand extended by the period for which such conditions lasts. If deliveries of bought out items and/or works to be executed by the CONTRACTOR are suspended by Force Majeure conditions lasting for more than 2 (two) months the OWNER shall have the option to terminate the CONTRACT or re-negotiate the contract provisions.

OUTBREAK OF WAR

(i) If during the currency of the CONTRACT there shall be an out-break of war whether declared or not, in that part of the World which whether financially or otherwise materially affect the execution of the WORK the CONTRACTOR shall unless and until the CONTRACT is terminated under the provisions in this clause continue to use his best endeavour to complete the execution of the WORK, provided always that the OWNER shall be entitled, at any time after such out-break of war to terminate or re-negotiate the CONTRACT by giving notice in writing to the CONTRACTOR and upon such notice being given the CONTRACT shall, save as to the rights of the parties under this clause and to the operation of the clauses entitled settlement of Disputes and Arbitration hereof, be terminated but without prejudice to the right of either party in respect of any antecedent breach thereof.

(ii) If the CONTRACT shall be terminated under the provisions of the above clause, the CONTRACTOR shall with all reasonable diligence remove from the SITE all the CONTRACTOR's equipment and shall give similar facilities to his SUB-CONTRACTORS to do so.

35.2 If the CONTRACTOR suffers delay in the due execution of the contractual obligations due to delays caused by force majeure as defined above, the agreed time of completion of job covered by this CONTRACT or the obligation of the CONTRACTOR shall be extended by a period of time on account of force majeure conditions, provided that on the occurrence of any such contingency, the CONTRACTOR within
120 hours reports to the OWNER in writing, the cause of delay and likely duration of cause of delay with requisite documentary evidence.

35.3 Should one or both the parties be prevented from fulfilling the contractual obligations by a state of FORCE MAJEURE lasting continuously for a period of 6 weeks, the two parties shall consult each other regarding the future implementation of the CONTRACT. The mere shortage of labour, materials or utilities shall not constitute FORCE MAJEURE unless caused by circumstances which are themselves FORCE MAJEURE.

35.4 CONTRACTOR and OWNER shall endeavour to prevent, overcome or remove the causes of FORCE MAJEURE.

35.5 No ground for exemption can be invoked if CONTRACTOR has failed to give timely notice by registered letter/ Speed-Post/Courier/Email/Fax/Hand Delivery and subsequently supported it by documentary evidence.

35.6 Delay or non-performance by a party hereto caused by the occurrence of any event of FORCE MAJEURE shall not:

(a) Constitute a default or breach of the CONTRACT,
   Or

(b) Give rise to any claim for damages or additional cost or expense occasioned thereby, if such delay or non-performance is caused by the occurrence of any event of FORCE MAJEURE. FORCE MAJEURE conditions are not payable under any circumstances.

35.7 Force Majeure is no one’s fault, therefore each party should bear its own cost and a provision to terminate the CONTRACT in case of Force Majeure extending beyond six (06) months is provided. Should OWNER wish the CONTRACTOR to continue further, both parties may sit together and mutually agree on the future course failing which Parties will have the right to terminate. Such termination shall not be considered as Termination for Owner’s Convenience. However, outstanding invoices, payment for supplies made and payment to the work already performed will be paid by OWNER on such termination and shall be detailed at the time of CONTRACT finalisation.

Contractor shall have the right to take action to mitigate the impact of the prolonged Force Majeure event in mutual consent with Owner; for instance Contractor shall have the right to demobilize Contractor’s equipment and personnel from the Plant.

36.0 NO WAIVER OF RIGHTS

Neither the inspection by the OWNER or any of their officials, employees, or agents nor any order by the OWNER for payment of money or any payment for or acceptance of, the whole or any part of the WORKS by the OWNER nor any extension of time, nor any possession taken by the OWNER shall operate as a waiver of any provision of the CONTRACT, or of any power herein reserved to the owner or any right to damages herein provided, nor shall any waiver of any breach in the CONTRACT be held to be a waiver of any other subsequent breach.
37.0 BANKRUPTCY AND LIQUIDATION OF CONTRACTOR OR BUSINESS UNDER RECEIVERSHIP

If the CONTRACTOR becomes insolvent or bankrupt, or has a receiving order made against him, or compound with his creditors, or being a corporation commence to be wound up not being a member's voluntary winding up for the purpose of reconstruction or carry on his business under a receiver for the benefit of his credit, the CONTRACTOR shall within fourteen (14) days notify the OWNER accordingly. On the occurrence of any of the happenings stated in the first sentence of this clause, the OWNER shall be at liberty to:

a) Determine the CONTRACT forthwith by notice in writing to the CONTRACTOR or to the receiver or liquidator or to any person in whom the CONTRACT may have become vested, and act in the manner provided in clause 34.1 (proceedings or default) or,

b) Give to such receiver liquidator or other person in writing the option for a period of one month of carrying out the WORK subject to his providing a guarantee for the due and faithful performance of the CONTRACT upto the CONTRACT value of the work for the time being remaining unexecuted and subject to his taking all reasonable steps to prevent stoppage of the work. In the event of stoppage of the work, the period of the option under this clause shall be fourteen (14) days only.

38.0 CERTIFICATE NOT TO AFFECT RIGHT OF OWNER AND LIABILITY OF CONTRACTOR.

No interim payment certificate of the OWNER nor any sum paid on account by the OWNER nor any extension of time for execution of the WORKS granted by the OWNER shall affect or prejudice the rights of the OWNER against the CONTRACTOR or relieve the CONTRACTOR of his obligations for the due performance of the CONTRACT or be interpreted as approval of the WORK done or of the equipment furnished and no certificate shall create liability on the OWNER to pay for alterations, amendments, variations, or additional works not ordered, in writing, by the OWNER or discharge the liability of the CONTRACTOR for the payment of damages whether due certified or not or any sum against the payment of which he is bound to indemnify the OWNER and the Consultant nor shall any such certificate nor the acceptance by him of any sum paid on account or otherwise affect or prejudice the rights of the CONTRACTOR against the OWNER.

39.0 SETTLEMENT OF DISPUTES

39.1 Except as otherwise specifically provided in the CONTRACT, all disputes concerning questions of fact arising under the CONTRACT shall be considered by the OWNER subject to a written appeal by CONTRACTOR to the OWNER.

39.2 Any disputes or differences including those considered as such by only of the parties arising out of or in connection with the CONTRACT shall be to be extent possible settled amicably between the parties.

39.3 If, after 60 DAYs from the commencement of such informal negotiations, OWNER and CONTRACTOR are unable to resolve amicably the dispute, either party may require that
the dispute be referred for resolution to the arbitration as described under clause 40 below.

40.0 ARBITRATION

40.1 Refer clause no 45 of Section-III of NIT

40.2 Continuation of Work and payments during Arbitration

WORK shall be continued by CONTRACTOR during the arbitration proceedings unless the matter itself is the subject of Arbitration or unless the matter itself is such that WORK cannot practically be continued until the decision of the arbitrator is obtained and CONTRACTOR shall remain liable and bound in all respects under the Contract. Except as otherwise expressly provided in CONTRACT, no payment due and payable by OWNER shall be withheld on account of such arbitration proceedings unless it is the subject matter or one of the subject matters.

40.3 FOR THE SETTLEMENT OF DISPUTES BETWEEN GOVERNMENT DEPARTMENT AND ANOTHER AND ONE GOVERNMENT DEPARTMENT AND PUBLIC ENTERPRISE AND ONE PUBLIC ENTERPRISE AND ANOTHER THE ARBITRATION SHALL BE AS FOLLOWS:

In the event of any dispute or difference between the parties hereto, such dispute or difference shall be resolved amicably by mutual consultation or through the good offices of empowered agencies of the Government. If such resolution is not possible, then, the unresolved dispute or difference shall be referred to arbitration of an arbitrator to be nominated by Secretary, Department of Legal Affairs ("Law Secretary") in terms of the Office Memorandum No.55/3/1/75 CF, dated the 19th December 1975 issued by the Cabinet Secretariat (Department of Cabinet Affairs), as modified from time to time. The Arbitration Act 1940 (10 of 1940) shall not be applicable to the arbitration under this clause. The award of the Arbitrator shall be binding upon parties to the dispute. Provided, however, any party aggrieved by such award may make a further reference for setting aside or revision of the award to Law Secretary whose decision shall bind the parties finally and conclusively.

41.0 GOVERNING LAWS, LANGUAGE AND MEASURES

41.1 CONTRACT shall be governed and construed according to the Indian Law as in force and shall be subject to the jurisdiction of the Court in Delhi. All disputes arising during the execution of the CONTRACT shall be resolved as per Clause no. 39.0 (Settlement of Dispute) & 40.0 (Arbitration) of GCC and thereafter in accordance with said law.

41.2 The governing language for all communication, notices, Technical Information, etc. pertaining to CONTRACT shall be English. Any literature, correspondence, documents, etc., shall be considered only if its accompanied by English translation. For the purpose of interpretation English translation shall govern and be binding on all parties.

41.3 The metric system of measurement shall be used exclusively in the CONTRACT.
42.0 RELEASE OF INFORMATION

The CONTRACTOR shall not communicate or use in advertising, publicity, sales releases or in any other medium, photographs or other reproduction of the WORKS under this CONTRACT or descriptions of the SITE, dimensions, quantity, quality or other information, concerning the work unless prior written permission has been obtained from the OWNER. Notwithstanding the above, CONTRACTOR is entitled, under intimation to OWNER, to make such public Announcements, as it may be bound to in compliance with the Law, the Rules and any Governmental Agency or Stock Exchange Regulation the CONTRACTOR is subjected to.

43.0 COMPLETION OF CONTRACT

Unless otherwise terminated under the provisions of any other relevant clause, this CONTRACT shall be deemed to have been completed at the expiry of the DEFECT LIABILITY PERIOD.

44.0 ENFORCEMENT OF TERMS

The failure of either party to enforce at any time any of the provisions of this CONTRACT or any rights in respect thereto or to exercise any option herein provided, shall in no way be construed to be a waiver of such provisions, rights or options or in any way affect the validity of the CONTRACT. The exercise by either party of any of its rights herein shall not preclude or prejudice either party from exercising the same or any other right provided in the contract.

45.0 OWNER’S DECISION

45.1 In respect of all matters which are left to the decision of the OWNER/ ENGINEER-IN-CHARGE including the granting or withholding of the certificates, the OWNER/ ENGINEER-IN-CHARGE shall, if required to do so, by the CONTRACTOR, give in writing a decision thereon.

45.2 In each case involving a financial commitment the written APPROVAL of the owner alone shall be binding.

45.3 In matters of difference of opinion on a decision passed by the OWNER/ ENGINEER-IN-CHARGE to the CONTRACTOR, stipulations of Clause 39.0 of GCC shall govern.
46.0 CO-OPERATION

46.1 CO-OPERATION WITH OWNER

The CONTRACTOR and OWNER shall co-operate with each other in the discharge of their respective obligation under the CONTRACT with the aim of satisfactorily completing the PLANT and the WORKS in accordance with the CONTRACT.

46.1.1 The parties shall deal fairly, openly and in good faith with each other. Subject to Clause 53 (Secrecy) of GCC, each party shall disclose information which the other might reasonably need in order to exercise its rights and to perform its obligations under the CONTRACT. In particular, each party shall promptly disclose full information to the other concerning any matter which will or may prevent the Plant and Works being completed in accordance with the CONTRACT. The parties shall work together in a manner consistent with their respective obligations under the CONTRACT to resolve or mitigate any such problem.

46.1.2 OWNER shall be at liberty to object with reasonably valid reasons to employment of any person at SITE and the objection shall be communicated in writing and CONTRACTOR shall make immediate arrangements for removal of such person.

46.2 COOPERATION WITH OTHER CONTRACTORS

The CONTRACTOR shall not object to the execution of the work by other contractors or tradesmen engaged by OWNER and offer them every facility for the execution of their several works simultaneously with CONTRACTOR’s work, provided however that CONTRACTOR’S WORK is not hampered by such co-operation. CONTRACTOR shall at all times provide sufficient fencing, notice boards, lighting and watchmen to protect and warn the public and guard the works and in default thereof, OWNER may provide such facilities at CONTRACTOR’s cost, if such failure is attributable to CONTRACTOR.

The CONTRACTOR shall agree to cooperate with the OWNER and OTHER CONTRACTORS and exchange with them such technical information, provided that such CONTRACTOR is bound towards CONTRACTOR on confidentiality and limited use obligations not less stringent than those accepted by OWNER under the CONTRACT and shall not be a competitor of CONTRACTOR as is necessary to obtain the most efficient and economical design and to avoid unnecessary duplication of efforts. The OWNER shall be provided with three (3) copies of all correspondence addressed by the CONTRACTOR to other SUB-CONTRACTORS in respect of such exchange of technical information.

47.0 SUSPENSION OF WORK

47.1 The OWNER reserves the right to suspend and reinstate execution of the whole or any part of the WORK without invalidating the provisions of the CONTRACT. Orders for suspension or reinstatement of the WORKS will be issued by the OWNER to the CONTRACTOR in writing. The time for completion of the WORKS will be extended for
a period equal to the duration of the suspension along with mutually agreed remobilization period.

47.2 If such suspension of WORK by OWNER delays or is likely to delay the progress of WORK or the carrying out of WORK under CONTRACT resulting in additional expenses or increased liability to CONTRACTOR, the OWNER shall pay to the CONTRACTOR all reasonable expenses, mutually agreed between OWNER and CONTRACTOR, arising from suspension of the work by an order in writing of the OWNER provided that such suspensions of work is more than a cumulative period of Sixty days (60) days and provided that such suspension is not due to some fault on the part of the CONTRACTOR or a SUB-CONTRACTOR.

47.3 If the OWNER has;
(i) failed to pay the CONTRACTOR any sum due under the CONTRACT within the period specified in the Contract; or (ii) failed to approve invoice or supporting document without just cause within the period specified in the Contract; or (iii) committed substantial breach of the Contract:
Then, CONTRACTOR may give a notice requesting OWNER to remedy aforesaid default within 30 days. If OWNER fails to remedy it within the said period, CONTRACTOR may suspend the performance of its obligations under the CONTRACT.

47.4 If the CONTRACTOR's performance of its obligations is suspended under the CONTRACT pursuant to clause 47.3 of GCC, then the GUARANTEED COMPLETION TIME shall be extended and all reasonable additional costs or expenses incurred by the CONTRACTOR and mutually agreed between OWNER and CONTRACTOR, as a result of such suspension shall be paid by the OWNER to the CONTRACTOR provided that such suspension is not due to fault on the part of CONTRACTOR or its SUB CONTRACTOR.

48.0 REPLACEMENT OF PARTS AND MATERIALS DEFECTIVE/DAMAGED/LOST DURING TRANSIT/ERECTION AND COMMISSIONING.

48.1 If during the progress of the WORK, the OWNER shall decide and inform in writing to the CONTRACTOR that the CONTRACTOR has manufactured any plant or part of the plant unsound or imperfect or has furnished any plant inferior to the quality specified, the CONTRACTOR on receiving details of such defects or deficiencies shall at his own expense, within seven (7) days of his receiving the notice or otherwise within such time as may be reasonably necessary for making it good, proceed to alter, reconstruct or remove such work and furnish fresh equipment upto the standards of the specifications. In case the CONTRACTOR fails to do so, the OWNER may, on giving the CONTRACTOR seven (7) days notice in writing of his intentions to do so, proceed to remove the portion of the works so complained of and at the risk & cost of the CONTRACTOR, perform all such work or furnish all such equipment provided that nothing in this clause shall be deemed to deprive the OWNER of or affect any rights under the CONTRACT which the OWNER may otherwise have in respect of such defects and deficiencies.
48.2 The CONTRACTOR's full and extreme liability under this clause shall be satisfied by the payments to the OWNER of the extra cost, of such replacement procured including erection as provided for in the CONTRACT, such extra cost being the ascertained difference between the price paid by the OWNER for such replacements and the CONTRACT price portion for such defective plants and repayments of any sum/ paid by the OWNER to the CONTRACTOR in respect of such defective plant.

48.3 If the material/ equipment or any portion thereof is damaged or lost during transit and handling, storage, erection, commissioning at site, the replacements of such material / equipment shall be effected by the CONTRACTOR within a reasonable time to avoid unnecessary delay in the COMMISSIONING of the EQUIPMENT and without waiting for realisation of cost of damages from the insurance company, appointed by him for this purpose. This will not alter the schedule of commissioning & guarantee tests in any way.

49.0 DEFENCE OF SUITS

49.1 If any action in Court is brought against the OWNER or an officer or agent of the OWNER for the failure omission or neglect on the part of the CONTRACTOR to perform any acts, matters, covenants or things under the CONTRACT, or for damage or injury caused by the alleged omission or negligence on the part of the CONTRACTOR, his agents representatives or his SUB-CONTRACTORS or in connection with any claim based on lawful demands of SUB-CONTRACTORs, workmen, suppliers or employees, the CONTRACTOR shall indemnify and keep the owner and/ or his representative harmless from all losses damages, expenses or decrees arising out of such action.

49.2 If any action in court referred to in Clause 49.1 of GCC above is brought against OWNER or an officer or agent of OWNER, OWNER shall promptly give the CONTRACTOR notice thereof and CONTRACTOR may at its own expense and in OWNER's name, conduct such proceedings or claim for the settlement of any such proceedings or claim. If CONTRACTOR fails to notify OWNER within twenty-eight (28) days after receipt of such notice that it intends to conduct any such proceedings or claim, then the OWNER shall have full power and right at his discretion to defend or comprise any suit or pay claim or demand brought or made against him as aforesaid whether pending or threatened as he may consider necessary or desirable and shall be entitled to recover from the CONTRACTOR all sums of money including the amount of damages and compensation and all legal costs, charges and expenses in connection with any compromise or award which shall not be called into question by the CONTRACTOR and shall be final and binding upon him provided however that, unless CONTRACTOR has so failed to notify OWNER within the twenty-eight (28) days period, OWNER shall make no admission which may be prejudicial to the defence of any such proceedings or claim.

50.0 CONTRACTOR’S RESPONSIBILITIES

50.1 In consideration of payment by the OWNER, the CONTRACTOR shall regularly and diligently carry out and complete the WORKS in accordance with the CONTRACT.
50.2 All work carried out by the CONTRACTOR shall be carried out with sound workmanship and materials, safety and in accordance with the Contract requirements.

50.3 The CONTRACTOR shall set out the PLANT by reference to points, lines and levels of reference as defined in the approved SPECIFICATION.

50.4 The PLANT/WORKS as completed by the CONTRACTOR shall in every respect comply with the requirements defined in the Specification or any other provision of the CONTRACT.

50.5 If any time during the performance of the CONTRACT the CONTRACTOR is of the opinion that a change to the WORKS or the design or method of operation of the PLANT
a. is necessary to eliminate a potential defect in the PLANT or a specific hazard to any person or party in the performance of the WORKS or in the operation of the PLANT which has occurred or would otherwise occur' or
b. would improve operating or life cycle costs of the PLANT; or
c. would otherwise be beneficial to the OWNER;
the CONTRACTOR shall bring the matter to the attention of the ENGINEER-IN-CHARGE stating the reasons for his opinion and where appropriate, submit his proposals for a Variation in accordance with Clause 3 of SPECIAL CONDITIONS OF CONTRACT.

50.6 The CONTRACTOR shall at all times have and maintain adequate resources available for the proper and timely execution of the WORKS, including financial resources, and competent, appropriately experienced and physically capable staff and labour whether employed by the CONTRACTOR, any SUB-CONTRACTOR or third parties.

50.7 The CONTRACTOR shall provide and maintain records as specified in the CONTRACT. Unless otherwise agreed, the CONTRACTOR shall, at intervals of not more than one calendar month, report to the ENGINEER-IN-CHARGE on the progress of the WORKS, supporting his reports with appropriate documentation including any revisions to the approved programme.

50.8 The CONTRACTOR shall maintain and cause SUB-CONTRACTORs to maintain, a quality assurance system as specified in the CONTRACT. The existence of such a quality assurance system shall not relieve the CONTRACTOR from any of his other duties, obligations or liabilities under the CONTRACT. The CONTRACTOR shall also prepare and implement a validation plan, if such a requirement is specified in the CONTRACT.

51.0 PROGRESS REPORTS AND PHOTOGRAPHS

51.1 The CONTRACTOR shall furnish soft copy of progress photographs of the work done in his shop/site. Photographs shall be taken when and where indicated by the ENGINEER-IN-CHARGE. Photographs, if required shall be approximately 8 inches by 10 inches in size, including a margin on one 10 inch side for binding. Each
51.2 Required number of monthly progress reports, in prescribed proforma, shall be submitted by the CONTRACTOR to the ENGINEER-IN-CHARGE for review. These shall detail the status of design, procurement of raw materials and bought outs, approval of the CONTRACTOR's drawings, manufacture of the equipment, statutory approvals taken, inspection of equipment/material, completed despatches, materials received at site, damages, if any, during transit, actions taken or replacement of damaged equipment, progress of erection work and programme of work for succeeding month and statement showing position of payment.

52.0 SPARES

All the necessary commissioning spares, Mandatory/Insurance spares shall be included in the scope of CONTRACT as listed in SectionVI-10.0 of NIT.

53.0 SECRECY

The technical information, drawings, specifications and other related documents forming part of the NIT or the CONTRACT or such of those materials prepared during the execution of the project including photographs, micro-films, design, calculations etc. are the property of the OWNER and shall not be used for any other purpose, except for execution of contract. All rights, including rights in the event of grant of a patent and registration of designs are reserved. The technical information, drawings, specifications, records and other documents shall not be copied, transcribed, traced or reproduced in any other form or otherwise in whole and/or duplicated, modified, divulged and / or disclosed to a third party nor misused in any other form whatsoever, without the OWNER's previous consent in writing except to the extent required for the execution of this CONTRACT. Such technical information, drawings specifications and other related documents furnished shall be returned to the OWNER with all approved copies and duplicates, if any, immediately after they have been used for the agreed purposes.

For avoidance of any doubt it may be clarified that this clause relate to documents prepared by OWNER.

In the event of any breach of this provision, the CONTRACTOR shall indemnify the OWNER from any loss, cost or damage or any other claim whatsoever from any parties claiming from or through them in respect of such breach.

All intellectual property rights in documents and calculations prepared by CONTRACTOR shall at all times exclusively vest with CONTRACTOR and be used by OWNER in accordance with the CONTRACT.

53.2 Records of Contract Documents

53.2.1 The CONTRACTOR shall at all times make and keep sufficient copies of the DRAWINGS, Specifications and CONTRACT documents for him to fulfil his duties under the CONTRACT.
53.2.2 The CONTRACTOR shall keep at site at least three copies of each and every Drawing, Specification and CONTRACT Document in excess of his own requirement and those copies shall be available at all times for use by the OWNER and EIC and by any other person authorized by the OWNER who have a need to know the same for the PROJECT, who shall be provided an adequately sized site office or offices, for the safekeeping and use of such documents, by the CONTRACTOR throughout the duration of the CONTRACT. Where one or more of CONTRACTOR’S yards/offices/offshore spreads are deployed in the WORKS, all requirements of the CONTRACT and CONTRACTOR’S obligation under the CONTRACT shall apply equally at each yard/office/offshore spread so deployed.

54.0 CORRESPONDENCE

54.1 All correspondence from the CONTRACTOR to the OWNER shall be as per the correspondence distribution schedule. All communications including technical-commercial clarification and/or comments shall be addressed to OWNER/PMC and shall always bear reference to CONTRACT.

54.1.1 Correspondence on technical and commercial matters shall be dealt with in separate letters and each copy of the letter shall be complete with all Annexure, if any.

54.2 Any notice to the CONTRACTOR under the terms of the CONTRACT shall be served by registered e-mail/Speed Post, fax or courier.

54.3 Any notice to the OWNER shall be served from the CONTRACTOR's Principal office in the same manner.

54.4 Any written order or instruction of OWNER or his duly authorised representative, communicated to authorised representative of the CONTRACTOR at site office shall be deemed to have been communicated to the CONTRACTOR at his legal address.

54.5 A notice shall be effective when delivered or on date of the notice, whichever is later.

55.0 MATERIALS AND EQUIPMENT

55.1 Materials

55.1.1 CONTRACTOR shall supply, to the OWNER, all materials required for incorporation in the permanent works as determined by the CONTRACTOR, within the scope of work, necessary to establish, commission and operate (so far as concerns mandatory/insurance spares) the PLANT/ Unit delivered on FOT Site basis.

55.1.2 INVOICES

CONTRACTOR’s invoices shall be raised as per approved Billing Schedule.

(a) The CONTRACTOR’s invoice shall be in the format with all the requisite information as prescribed under GST Laws.

(b) Before raising GST invoices, CONTRACTOR shall coordinate with the OWNER with respect to address and GSTIN number on which such invoices have to be raised.
55.1.3 The CONTRACTOR shall be responsible at his own cost and initiative within the scope of services, to take delivery of the materials from the port of delivery in India in respect of imported materials and from the factory or ware-house or other place(s) of delivery in respect of indigenous materials and to transport these to the CONTRACTOR's stockpiles, godowns or other places of storage approved by the ENGINEER-IN-CHARGE, and to transport the same from said godowns or place(s) of storage to the work site for installation in the permanent WORKS.

55.1.4 The work of delivery and transportation of materials shall include (but not be limited to) the following:

i) Clearance of the goods through custom and port clearance including filling and/or filing of all custom manifests, bills of entry, and custom declarations and other documents as may be required for the clearance of the goods from customs or port authorities, for which purpose the OWNER shall, from time to time, grant to the CONTRACTOR or the CONTRACTOR's designate(s), such authority(ies) as may be reasonably required by the CONTRACTOR in this behalf.

ii) Stevedoring, clearing, forwarding and handling services as required for clearing, forwarding and handling imported and indigenous materials and consignments including payment at CONTRACTOR's cost of any demurrage, wharfage, port charges, siding charges, retention charges, detention charges or other charges whatsoever and howsoever designated or levied by any railway, air-port, ship and/or other authorities for or in connection with the loading, unloading or detention of any materials or vessels or other means of transport beyond the free period or unloading, clearance, retention or detention or loading, as the case may be, provided by the relevant authority(ies) or carrier(s) in this behalf.

iii) All works and operations necessary to lift and to remove the material from port, ware-house, railway or other siding, factory or other places of delivery, loading, handling, transporting and unloading and safely stacking, placing or storing the same at approved godowns, yards or other place(s) of storage including lashing or otherwise securing or protecting the same in transit and during and in storage.

iv) Supply, procurement, mobilization, and deployment of all labour thereof, equipment & machinery necessary for lifting, loading, handling, removing, transporting, unloading, stacking or securing the materials.

v) Transit and storage insurance of all materials for the full replacement value thereof delivered at site.

vi) All acts, deeds, matters or things required to fulfil all local, municipal and other statutory authorities with respect to the transportation of any materials through or into any State, municipal, local or other barriers or limits or for the import of the materials or any of them within the limits of such barrier, including payment of octroi or other local toll, terminal and/or entry or other taxes payable on the passage or entry of the materials through or within any local limits, for which purpose the OWNER shall give the CONTRACTOR and/or CONTRACTOR's designate(s) any and all authority(ies) as may be reasonably required in this behalf.
vii) All other acts, deeds, matters and things whatsoever ancillary, auxiliary or incidental to the above including but not limited to the grading of the site and/or creation of temporary approaches and ramps etc. as may be required.

55.2 GENERAL PROVISION WITH REGARD TO MATERIALS

55.2.1 The CONTRACTOR shall, within the scope of work, undertake the following activities and responsibilities with respect to and in addition and without prejudice to the activities and responsibilities under Clause 55.1.0 and associated clauses thereunder in respect of materials:

i) The CONTRACTOR shall in taking delivery, ensure compliance of any condition for delivery applicable to deliveries from the concerned authority or carrier, and shall be exclusively responsible to pay and bear any detention, demurrage or penalty or other charges payable by virtue of any delay or failure by the CONTRACTOR in lifting the materials or in observing any of the conditions aforesaid, and shall keep the OWNER indemnified from and against all consequences thereof.

ii) The CONTRACTOR shall maintain a day-to-day account of all materials indicating the daily receipt(s), consumption(s) and balance of each material and category thereof. Such account shall be in the format, if any, prescribed by the ENGINEER-IN-CHARGE and shall be supported by all documents necessary to verify the correctness of the entries in the account. Such account shall be maintained at the CONTRACTOR MANAGER’s office and site(s) and shall be open for inspection and verification (by verification of documents in support of the entry as also by feasible verification of the stock) at all times by the ENGINEER-IN-CHARGE with authority at all times without obstruction to enter into or upon any godown or other place(s) or premise(s) where the materials or any part of them are lying or stored and to inspect the same himself and or through his representative(s).

iii) All materials shall be taken delivery of, held, stored and utilised by the CONTRACTOR as Trustee of the OWNER, and delivery of the material to the CONTRACTOR shall constitute an entrustment thereof to the CONTRACTOR, with the intent that any utilization, application or disposal thereof by the CONTRACTOR otherwise than for permanent incorporation in the contractual works in terms of the contract shall constitute a breach of trust by the CONTRACTOR.

iv) DELETED

v) The CONTRACTOR shall at all times be exclusively responsible for any and all losses, damages, deterioration, misuse, wastage, theft, or other application or misapplication or disposal of the materials or any of them contrary to the provisions hereof and shall keep the OWNER indemnified from and against the same and shall forthwith at its own cost and expenses replace any such material, lost, damaged, deteriorated, misused, wasted, stolen, applied, mis-applied and/or disposed as aforesaid with other material of equivalent quality and quantity delivered to site at the CONTRACTOR’s risks and costs in all respects.
vi) The CONTRACTOR shall take out, at his own cost and keep in force at all times, during transit, handling, storage, and erection up to completion in all respect of the work, policy (ies) with Insurance Company (ies) approved by the OWNER for the full replacement value of the materials at site against the risks specified in the CONTRACT. Such policies shall be in the joint names of the OWNER and the CONTRACTOR, with exclusive right in the OWNER to receive all monies due in respect of such policy (ies) and with right in the OWNER (but without obligation to do so) to take out and pay the premia for any such policy (ies) and deduct the premia and any other costs and expense in this behalf from the monies for the time being due or in future becoming due to the CONTRACTOR. In case of Insurance claim, the GST leviable on the transfer of the claim money from OWNER to CONTRACTOR shall be over and above the GST cap indicated in the CONTRACT and shall be borne by OWNER.

vii) Deleted

viii) If the CONTRACTOR shall default in replacing at the job SITE, without any additional cost to the OWNER, any material lost, damaged, deteriorated, misused, wasted, short, stolen, misapplied or disposed of within the provisions hereof above, the CONTRACTOR shall be liable to pay to the OWNER the cost of such materials.

a) Notwithstanding anything herein provided, the CONTRACTOR shall be and remain solely and exclusively liable to repair, restore or replace, as the case may be, the materials damaged or destroyed as a result of any act or omission, notwithstanding the existence or otherwise of any policy(ies) of insurance aforesaid, with the intent that any policy(ies) of insurance aforesaid taken out by the CONTRACTOR or by the OWNER, on default by the CONTRACTOR, shall not anywise absolve the CONTRACTOR from his full liability up to and until issue of the Preliminary Acceptance Certificate as provided for herein in respect of the works, the work(s) and all materials incorporated therein shall be and remain at the risks of the CONTRACTOR in all respects, including (but not limited to) accident, lightning, earth-quake, fire, storm, flood, tempest, riot, civil commotion and/or war or otherwise with respect to the materials, but shall constitute merely an additional security and not a substitution of liability.

b) It shall be the exclusive responsibility of the CONTRACTOR to lodge and pursue any or all claims in respect of the insurance aforesaid.

c) The CONTRACTOR shall, as a condition to the certification of any Running Account Bill, satisfy the OWNER/ Engineer-In-Charge of the existence of one or more policy(ies) of insurance, covering the materials as specified herein. The policy(ies) of insurance aforesaid shall cover all insurable risks, including but not limited to, any loss or damage commencing from the supplier’s ware house in handling, transit, storage and during erection, theft, pilferage, riot, civil commotion, force majeure (including earth quake, flood, storm, cyclone, tidal wave, lightening and other adverse weather conditions), accidents of kinds, fire, war risks and explosion.

ix) DELETE
55.3.0 **BILL OF MATERIALS**

55.3.1 The CONTRACTOR shall furnish to the OWNER a detailed Bill of Materials specifying the materials, which on preliminary determination made by the CONTRACTOR, will be required to be incorporated in the permanent works in order to establish the WORK/Unit and to operate the PLANT/Unit, including construction materials.

55.3.2 Each item entered in the Bill of Materials shall be priced. The Bill of Materials and said price break–up therein are intended only to form a basis for the purpose of calculating on account payments and for calculating payments due to the CONTRACTOR under Clause 34.0 of GCC upon cancellation of contract, and for no other purpose.

55.3.3 The OWNER shall review or cause to be reviewed the prima facie adequacy, sufficiency, validity and/or suitability of the materials listed in the Bill of Materials for the works for which they are intended, and of the prices indicated in the Bill of Materials in respect thereof. Such review shall be performed in conjunction with the design, engineering, specification and other technical reviews to be done by the OWNER and all provisions applicable thereto with reference to critical drawings shall be applicable to the review of the Bill of Materials.

55.3.3.1 The priced Bill of Materials as approved by the OWNER shall constitute the Bill of Materials envisaged in the contract documents. However, no such approval shall, in any manner, absolve the CONTRACTOR of his full responsibility under the CONTRACT to sell and supply to the OWNER all materials required for the permanent incorporation in the works and which are required to establish, commission and operate (to the extent of mandatory/insurance spares) the PLANT/Unit in accordance with the CONTRACT and the specifications, complete in all respects including spares, tools, tackles and testing equipment, so far as included within the scope of supply, whether or not any particular material is actually included within or omitted in the Bill of Materials and whether or not the price thereof is included in the price indicated in the Bill of Materials and whether or not the price thereof is in conformity with the price thereof indicated in the Bill of Materials. The review and approval of the Bill of Materials and the prices therein are intended only for the satisfaction of the OWNER that the priced Bill of Materials, prima facie covers the materials required to be supplied by the CONTRACTOR within the scope of supply.

55.3.4 The Bill of Materials shall be subject to amendment in both items and prices in so far as necessary consequent upon any amendment in any relevant related technical particulars, and upon any amendment, the amended Bill of Materials as approved by the OWNER, shall thereafter constitute the Bill of Materials as envisaged in the CONTRACT documents.

55.4 **SUPPLY OF MATERIALS**

55.4.1 The CONTRACTOR shall supply the materials required to be supplied within the Contractor’s scope of supply for incorporation in the permanent works in accordance with
and to meet the requirements in quality, quantity and other particulars of the descriptions, specifications, plans, drawings, designs and other documents applicable thereto, and the CONTRACTOR shall be deemed to have undertaken that all materials selected, procured and supplied by the CONTRACTOR within the scope of supply shall be of the best quality and workmanship and shall be capable of producing the designed desired results and to perform the designed and desired functions to meet the contractual requirements in all respects for the project.

55.4.2 The CONTRACTOR shall undertake and complete the supply of materials within the scope of supply to meet the scheduled progress and requirements of the WORK within the scope of work.

55.4.3 All materials shall be deemed to have been accepted only when the material is received at the project SITE and accepted by the ENGINEER-IN-CHARGE. Such acceptance shall however be subject to the terms and conditions of CONTRACT, including the right of rejection and/or replacement as elsewhere herein specified.

55.4.4 Without prejudice to any other terms of the contract, it is clarified that the mere agreement, acceptance or prescription of a Delivery or other Schedule containing an extended time of commencement or completion in respect of the entire delivery(ies) or any of them shall not anywise constitute an extension of time in a terms of the CONTRACT so as to bind the OWNER or relieve the CONTRACTOR of all or any of his liabilities under CONTRACT, nor shall constitute a promise on behalf of the OWNER or a waiver by the OWNER of any of its rights in terms of the contract relative to the performance of the CONTRACT within the time specified or otherwise, but shall be deemed only (at the most) to be a guidance to the CONTRACTOR for better organising his work on a recognition that the CONTRACTOR has failed to organise his supplies and/or make the same within the time specified in the Delivery Schedule.

55.4.5 If the CONTRACTOR fails to supply the materials in accordance with the dates in this behalf specified in the Delivery Schedule which has an impact on the critical path of the schedule, the CONTRACTOR shall provide the OWNER with a suitable plan to recover the delay, but without prejudice to any other rights, discount or remedy available to the OWNER in respect of such delay or failure.

55.4.6 MAKE OF MATERIALS

i) All equipment and materials to be supplied under this CONTRACT shall be from approved vendors as indicated in the Bidding Document or as otherwise approved by the ENGINEER-IN-CHARGE / OWNER.

ii) Where the makes of materials are not indicated in the Bidding document, the CONTRACTOR shall furnish details of proposed makes and supplies and supply the same after obtaining the OWNER's/ ENGINEER-IN-CHARGE's approval.

55.5.0 CERTIFICATE OF VERIFICATION AND GOOD CONDITION

55.5.1 The CONTRACTOR shall, before supply of material covered within the scope of supply, at his own risks, costs and initiative, undertake or cause to be undertaken all tests, analysis and inspections as shall be required to be undertaken with regard to the materials under the specifications and any codes, practices, orders and instructions with respect thereto and shall cause the results thereof to be recorded, reported or certified,
as the case may be, and shall not offer for delivery or deliver any material(s) which has/have not passed such tests/analysis or inspection and which are not accompanied by the tests results, reports and/or certificates in this behalf provided in the applicable specifications, code(s) and/or practices.

55.5.2 On arrival of the material at site the CONTRACTOR shall give written notice thereof to the ENGINEER-IN-CHARGE or Inspection Agency notified by the OWNER in this behalf, to inspect the materials, and shall keep in readiness for inspection, the materials and the relevant tests results, reports and certificates hereto.

55.5.3 Notwithstanding any other provisions in the contract documents for analysis or tests of materials and in addition thereto, the CONTRACTOR shall, if so required by the ENGINEER-IN-CHARGE or Inspection Agency in writing at his own risks and costs, analyse, test, prove and weigh all materials (including materials incorporated in the works) required to be analysed, tested, proved and/or weighed by the ENGINEER-IN-CHARGE or Inspection Agency in this behalf and shall have such analysis or tests conducted by the agency(ies), or authority(ies) if any specified by the ENGINEER-IN-CHARGE or Inspection Agency. The CONTRACTOR shall provide all equipment, labour, materials and other things whatsoever required for testing, preparation of the samples, measurement of work and/or proof of weighment of the materials as directed by the ENGINEER-IN-CHARGE or Inspection Agency.

55.5.4 If on Inspection or proof, analysis or tests as aforesaid the ENGINEER-IN-CHARGE or Inspection Agency nominated by the OWNER in this behalf is prima facie satisfied that the material received is in conformity with the material requirements of the Bill of Materials and description given in the shipping documents and in the CONTRACTOR’s invoices in this behalf and that the test reports/results/certificates given in respect thereof are prima facie in conformity with the relevant result/reports/certificates required in respect thereof in terms of the specifications and/or relevant codes and practices, and that the material appears to be prima facie in good order and condition, the ENGINEER-IN-CHARGE shall issue to CONTRACTOR, a Certificate of Verification and Good Condition in respect of such material, and this shall constitute the Certificate of Verification and Good Condition elsewhere envisaged in the CONTRACT documents. Should the ENGINEER-IN-CHARGE not issue said Certificate within 5 working days, following the conformity of the aforementioned requirements, the Certificate of Verification and Good Condition shall be deemed issued.

55.5.5 Such certificate is only intended to satisfy the OWNER that prima facie the material supplied by the CONTRACTOR is in order and shall not anywise absolve the CONTRACTOR of his/its full responsibility under the CONTRACT in relation thereto, including in relation to specification fulfilment and/or performance or other guarantees.

55.5.6 Notwithstanding that any area(s) or source(s) has/have been suggested by the OWNER to the CONTRACTOR from which any material for incorporation in the WORKS can be obtained, the CONTRACTOR shall independently satisfy himself of the suitability, accessibility and sufficiency of the source(s) of supply suggested by the OWNER and suitability of the material available from such source(s) with the intent that any suggestion as aforesaid shall not anywise relieve the CONTRACTOR of his full liability in respect of the suitability and quality of the material(s) obtained from said source(s) and the CONTRACTOR shall obtain material(s) there from and incorporate the same within the permanent works entirely at his own risks and costs in all respects, with the intent that any such suggestion by the OWNER shall only be by way of assistance to the CONTRACTOR and shall not entail any legal responsibility or liability upon the OWNER.
55.6.0 MATERIALS WITHIN THE CONTRACTOR’S SCOPE OF SUPPLY
55.6.1 The OWNER does not warrant or undertake the provisions of any materials and the CONTRACTOR shall not imply, by conduct, expression or assurance or by any other means, any promise or obligation on the part of the OWNER in his respect understood by the CONTRACTOR.

55.7.0 Deleted

55.8 PACKING AND FORWARDING

- The CONTRACTOR shall, wherever applicable, after proper painting, pack and crate all items in such a manner so as to protect them from deterioration and damage during rail and road transportation to the site and during storage at the site till the time of erection. Without prejudice to any other liabilities or obligations of the CONTRACTOR, the CONTRACTOR shall be responsible for all damage(s) due to improper packing.

- The CONTRACTOR shall notify OWNER/ ENGINEER-IN-CHARGE the expected date of arrival materials at the site for the information of OWNER/ ENGINEER-IN-CHARGE.

- The CONTRACTOR’s notification shall also give all shipping information concerning the weight, size and content of each packing and such other information as the OWNER/ ENGINEER-IN-CHARGE may require.

- The following documents shall be sent to the OWNER/ EIC in three copies:
  a) Signed Invoice(s)
  b) Delivery Challan
  c) Packing list.
  d) Manufacturer’s certificate of inspection for shipment duly approved by the CONTRACTOR in one original and one photocopy
  e) Third Party Inspection Release Note clearly indicating that material has been inspected and accepted as per QAP approved by OWNER, or waiver certificate issued by OWNER.
  f) Railway Receipt/LR
  g) Insurance Certificate/Intimation
  h) Guarantee certificate (wherever applicable)
  i) Operation & Maintenance manual (wherever applicable)

55.9 Deleted

55.10 Deleted

55.11 UTILITIES AND CONSUMABLES ETC.

55.11.1 Subject to any other provision to the contrary in the CONTRACT, the CONTRACTOR shall be and remain at all times exclusively responsible within the scope of work to
provide all utilities, consumables, permits, licenses, easements and facilities and other items and things whatsoever required for or in connection with the WORK, including but not limited to those indicated by expression or implication in the bid documents and/or other CONTRACT documents or howsoever otherwise as shall be or may from time to time be necessary for or in connection with the WORK.

56.0 MEASUREMENTS, CERTIFYING INSPECTIONS AND PAYMENTS

56.1 Final Measurements:

56.1.1 Within 15 (fifteen) days from the date of certification of works completed/milestone achieved in respect of the WORKS, or of any portion of the WORKS, section, group or job site, as the case may be, measurements for the works covered by such certification shall be jointly taken by the ENGINEER-IN-CHARGE and the CONTRACTOR as herein provided.

56.1.2 If the CONTRACTOR fails to apply to the ENGINEER-IN-CHARGE for measurements within 15 (fifteen) days from the date of certification of works completed/milestone achieved as specified in Clause 56.1.1, the ENGINEER-IN-CHARGE shall notify the CONTRACTOR in writing of the date(s) for measurements, and require the CONTRACTOR to be present on date(s) so notified.

56.2 Mode of Measurement:

56.2.1 All measurements shall be recorded in the metric system, and shall be taken in accordance with the procedures set forth or provided for in the Schedule of Rates, Specifications and other CONTRACT Documents.

56.2.2 Where the mode of measurement is not provided for in the Contract Documents in respect of any item of work, it shall be measured in accordance with the Indian Standard Specification No. 1200 (latest edition) and in the event of such item not being covered by Indian Standard Specifications, it shall be measured in accordance with the method of measurement in this behalf specified by the ENGINEER-IN-CHARGE, whose decision in this regard shall be final and binding upon the CONTRACTOR. If the Contractor disagrees with the decision of the ENGINEER-IN-CHARGE, the dispute shall be settled as per the provisions of Clause 39.0 of GCC.

56.2.3 All measurements shall be taken jointly by the ENGINEER-IN-CHARGE and the CONTRACTOR or their respective representatives. The CONTRACTOR or his authorized representative shall be entitled to remain present at all times when joint measurements are being taken.

56.2.4 Despite due intimation, if the CONTRACTOR omits or fails to be present to witness joint measurements, the measurements shall be taken in the presence of the ENGINEER-IN-CHARGE and the measurements so recorded and signed by the ENGINEER-IN-CHARGE as correct, shall be final and binding upon the Parties.

56.2.5 Except in cases covered by Clause 56.2.4, in all other cases measurements shall be signed and dated on each page by the CONTRACTOR / CONTRACT MANAGER and ENGINEER-IN-CHARGE or his representative. If the CONTRACTOR objects to any of the measurements recorded, including the mode of measurement, such objection shall be noted in the measurement book against the item objected to and such note shall be dated and authenticated by the CONTRACTOR / CONTRACT MANAGER and ENGINEER-IN-
56.2.6 All objections noted in the Measurement Book in terms of Clause 56.2.5 shall be considered and decided within 15 days by the ENGINEER-IN-CHARGE. The decision of the ENGINEER-IN-CHARGE relative thereto (whether on the correct measurement to be adopted or on the mode of measurement to be adopted) shall be final and binding upon the Parties. If the Contractor disagrees with the decision of the ENGINEER-IN-CHARGE, the dispute shall be settled as per the provisions of Clause 39.0 of GCC.

56.2.7 The measurement as finally recorded in terms of Clause 56.2.4 or Clause 56.2.5 or 56.2.6, as applicable, shall be the Final Measurement.

56.3 CERTIFYING INSPECTIONS

All provisions referred to in Clauses 56.1 to 56.2, in respect of Mode of Measurement, shall apply to all inspections required to be made in order to qualify the CONTRACTOR for any payment(s) under the CONTRACT and any reference in the said clauses to measurements shall, for the purpose of this clause, be deemed to be a reference to certifying inspections and any reference therein to the measurement book shall, for the purpose of this clause, be deemed to be a reference to the certifying inspection book.

56.4.0 FINAL BILL

56.4.1 On the basis of the LUMPSUM PRICE provided in the CONTRACT and subsequent Change Order(s)/Amendment(s), if any and the approved billing schedule, the CONTRACTOR shall prepare a Final Bill in the prescribed form. Additions claimed to the LUMPSUM PRICE or reductions thereof on account of CHANGE ORDER(s) shall be separately indicated in the Final Bill with reference to the relative CHANGE ORDERS(s).

56.4.2 The Final Bill shall, in addition to the payment entitlements arrived at according to the provisions of Clause 56.4.1 hereof shall separately state and include therein all claims of the CONTRACTOR, if any, with full particulars of the nature of such claim and grounds on which it is based and the amount claimed.

56.4.3 The Final Bill drawn in accordance with Clause 56.4.1 shall be submitted together with the PRELIMINARY ACCEPTANCE CERTIFICATE to the ENGINEER-IN-CHARGE for certification, who shall certify the Final Bill, if drawn in accordance with Clause 56.4.1. After certification of the ENGINEER-IN-CHARGE, the Final Bill shall be submitted in quadruplicate (or in such other number of copies as the OWNER may prescribe) accompanied by the PRELIMINARY ACCEPTANCE CERTIFICATE to the OWNER for payment.

56.4.4 All monies payable under the CONTRACT for WORKS to be performed and MATERIALS to be supplied up to and including successful completion and final tests and commissioning of the system and performance tests shall become due and payable to the CONTRACTOR only after submission to the OWNER of the Final Bill prepared in accordance with the provisions of Clause 56.4.1 hereof and associated provisions there under accompanied by the PRELIMINARY ACCEPTANCE CERTIFICATE in respect of the WORKS.
56.4.5 Payments of the amount(s) due on the Final Bill to the extent certified by the ENGINEER-IN-CHARGE, shall be made within 84 (Eighty Four) days from the due date as specified in Clause 56.4.4 hereof, subject to the deductions provided in Clause 56.4.5.1.

56.4.5.1 All payments due to the CONTRACTOR on the Final Bill shall be subject to, tax deductions as provided for in Clause 56.7.2 and associated clauses there under and any other deduction provided in the CONTRACT or required to be made under any law, rule or regulation having the force of law for the time being applicable, or elsewhere provided for in the CONTRACT documents.

56.5.0 PRICE SCHEDULE

56.5.1 The remuneration determined due to the CONTRACTOR as provided for in Clause 56.4.1 hereof shall constitute the entirety of the remuneration and entitlement of the CONTRACTOR in respect of the WORK under the CONTRACT, and no further or other payment whatsoever shall be or become due or payable to the CONTRACTOR under the CONTRACT.

56.5.2 Without prejudice to the generality of the provisions of Clause 56.5.1 hereof, the Price Schedule and LUMPSUM PRICE shall be deemed to include and cover (unless otherwise expressly specified to the contrary in any CONTRACT document(s)):

(i) All costs, expenses, outgoings and liabilities of every nature and description whatsoever and all risks whatsoever (foreseen or unforeseen, including force majeure) to be taken or which may occur in or relative to execution, completion, testing, commissioning and/or handling over the WORKS to the OWNER and/or in or relative to acquisition, loading, unloading, transportation, storing, working upon, using, converting fabricating, or erecting any item, equipment, system, material or component in or relative to the WORKS, and the CONTRACTOR shall be deemed to have known the nature, scope, magnitude and the extent of the works and items, MATERIALS, EQUIPMENT, and components required for the proper and complete execution of the Works though the CONTRACT documents may not fully and precisely set out, describe or specify them, and the generality hereof shall not be deemed to be anywise limited, restricted or abridged because in certain cases the CONTRACT documents or any of them shall or may and/or in other cases they shall or may not expressly state that the CONTRACTOR shall do or perform any particular labour or service or because in certain cases the CONTRACT documents state that a particular work, operation, supply, labour or service shall be performed/made by the CONTRACTOR at his own cost or without additional payment, compensation or charge or without entitlement of claim against the OWNER or words to similar effect, and in other cases they do not, or because in certain cases it is stated that the same are included in or covered by the Price Schedule and in other cases it is not so stated.

(ii) The cost of all construction and related vessels, craft, vehicles, movements, plant, equipment, distribution of water and power, construction of temporary roads and access, temporary works, pumps, wiring, pipes, scaffolding, piling, shuttering and other materials, supervision, labour, insurance, fuel, stores, spares, supplies, appliances and materials, items, articles and things whatsoever (foreseen of unforeseen) by expression or implication to be supplied, provided or arranged in or relative to or in connection with the performance and/or execution of the WORKS and/or related or incidental thereto, complete in every respect in
accordance with the CONTRACT document, and the plans, drawing, designs, orders and/or instructions;

(iii) The cost of mobilisation including but not limited to mobilisation of vehicles, movements, machinery, equipment, gear, tools, tackle, consumables and other items and goods and personnel necessary for or to perform the WORKS contemplated under the CONTRACT, preparation and erection of work yards and other work places and facilities necessary for or to perform the WORKS contemplated under the CONTRACT and/or to supply the material included within the scope of supplies including all work, labour, inputs, goods, EQUIPMENT, and other items and things whatsoever necessary for the performance of the WORKS, dismantling and/or removal of the same and restoration of the site, lifting the materials and transporting them to CONTRACTOR’s stock piles/work yard, job sites and loading, stacking and/or storing the same.

(iv) The costs and risks of all rents, royalties, licenses, permits, permission and other fees, duties, penalties, levies, and damages whatsoever payable for or in respect of any protected or patented goods, materials, equipment or processes employed in or relative to the works and of all rents, royalties, licenses, permits, permissions and any other fee, duty, penalty, levy, loss or damages payable on the excavation, removal or transportation of any material or acquisition or use of any right of way or other right, licenses, permit, privilege, permission or uses required for or relative to the performance of the WORK.

(v) The cost of all taxes and duties payable in India with regard to materials supplied by the CONTRACTOR within the scope of supplies, all customs and import duties, Indian Income Tax, applicable GST, quay, warfare, demurrage, detention and landing charges and all other duties, taxes, fees, charges, levies, and/or cesses whatsoever imposed or to be imposed by the Central Government or State Government or Municipal or Local Bodies or other Authorities whatsoever and payable on any materials supplied and/or on works performed without any entitlement to the CONTRACTOR for any exemption, remission, refund or reduction thereof.

(vi) The cost of all indemnities under the CONTRACT, and insurance primia on insurance required in terms of the CONTRACT documents or otherwise under any law, rule or regulation, and the cost of all risks whatsoever (foreseen and unforeseen) including but not limited to risks of delay or extension of time or reduction or increase in the work or scope of work and/or cancellation of CONTRACT, and/or accident, strike, civil commotion, war, strike, labour trouble, third party breach, fire, lighting, inclement weather, storm, tempest, flood, earthquake and other acts of God, Government regulation or imposition or restriction, dislocation of road, rail, sea, air and other transport, access or facility, flooding of site and/or access roads and approaches thereto, suspension of work, sabotage and other cause whatsoever.

(vii) The cost of all inspections, tests and certificates relative thereto including third party tests and/or inspections where necessary, and of items, instruments, plant and/or tools and appliances required to conduct such inspection and tests.

(viii) The cost of all materials supplied and/or intended for incorporation in the WORKS supplied within the scope of work, delivery thereof to the job site,
loading, transportation and unloading thereof, waste on materials, and return of empties and surpluses.

(ix) The cost of all escalations (foreseen and unforeseen) including but not limited to increase in Government taxes and duties (beyond contractual completion period and any extension hereof due to reasons attributable to CONTRACTOR), labor costs and material costs and other inputs whatsoever.

(x) All supervision charges, establishment's overheads, finance charges and other costs and expenses and charges to the CONTRACTOR, and the CONTRACTOR's profit of and relative to the WORK and/or supply.

(xi) The cost of all deductions, reductions, discounts, adjustments and withholdings whatsoever under or in connection with the CONTRACT.

(xii) The cost of all taxes & duties payable in India with regard to materials supplied by the CONTRACTOR within the scope of supplies, all customs and import duties, Indian Income Tax, applicable GST, quay, wharfage, demurrage, detention and landing charges and all other duties, taxes, fees, charges, levies, and/or cesses whatsoever imposed or to be imposed by the Central Government or State Government or Municipal or Local Bodies or other Authorities whatsoever and payable on any materials supplied and/or on works performed without any entitlement to the CONTRACTOR for any exemption, remission, refund or reduction thereof.

(xiii) The Schedule of Rates shall be deemed to include and cover the risk of all possibilities of delay and interference with the CONTRACTOR's conduct of WORK which occur from any causes including orders of the OWNER in the exercise of his power and on account of extension of time granted due to various reasons and for all other possible or probable causes of delay.

56.5.3 The rates stated in the Price Schedule and the lumpsum price(s) shall not be subject to escalation or increase for any reason whatsoever unless otherwise provided in the CONTRACT documents.

56.6.0 ADVANCE PAYMENT

56.6.1 Without prejudice to the provisions of Clause 56.4.4 hereof, the OWNER shall by way of assistance to the CONTRACTOR, make “advance” or “on account” payments to the CONTRACTOR during the progress of the work and/or supply on the basis of Running Account Bills or otherwise as elsewhere more specifically provided for in the CONTRACT documents. However, all payments shall be as per the payment terms agreed as per relevant clause.

56.6.2 The following provisions shall apply with respect to “advance” payments to the CONTRACTOR:

56.6.2.1 Advance(s), if any, paid to the CONTRACTOR shall carry interest at the rates specified in the SPECIAL CONDITIONS OF CONTRACT, and shall be adjustable (without prejudice to the any other mode of recovery) from the Running Account Bills of the CONTRACTOR as provided in the SPECIAL CONDITIONS OF CONTRACT.

56.6.2.2 The advances paid to the CONTRACTOR shall be used for execution of this contract only and the CONTRACTOR shall satisfy the OWNER in this regard whenever required. If it is found that an advance has been utilised by the CONTRACTOR in whole or part for any other purpose, the OWNER may at its discretion forthwith recall the entire advance and,
without prejudice to any other right or remedy available to the OWNER, recover the same by recourse to any Bank Guarantee(s).

56.6.3 Subject to the provisions of clause 34.0 of GCC, all advances made by the OWNER to the CONTRACTOR shall forthwith become repayable to the OWNER in the event of the CONTRACT being terminated for any cause.

56.7.0 MODE OF PAYMENT AND TAX DEDUCTIONS

56.7.1 All payments made under or in terms of the CONTRACT, shall be paid through Electronic Fund Transfer mechanism (EFT).

56.7.2 The CONTRACTOR shall be primarily responsible for the payment of all Indian Income tax.

56.8.0 CLAIMS BY THE CONTRACTOR

56.8.1 No claim(s) shall on any account be made by the CONTRACTOR after submission of the Final Bill, with the intent that the Final Bill prepared by the CONTRACTOR shall reflect any and all claims whatsoever of the CONTRACTOR against the OWNER arising out of or in connection with the CONTRACT or any supply made or work performed by the CONTRACTOR there under or in relation thereto, and notwithstanding any enabling provision in any law or CONTRACT and notwithstanding any claim that the CONTRACTOR could have with respect thereto, the CONTRACTOR hereby waives and relinquishes any and all such claims not included in the Final Bill and absolves and discharges the OWNER from and against the same, even if in not including the same as aforesaid, the CONTRACTOR shall have acted under a mistake of law or of fact, or shall claim to have acted under economic compulsion or necessity.

56.8.2 If required by the OWNER, the ENGINEER-IN-CHARGE shall be authorised to require the CONTRACTOR to furnish, and the CONTRACTOR shall, upon the request of the ENGINEER-IN-CHARGE /OWNER, furnish all invoices, vouchers and accounting records as may be deemed necessary by the ENGINEER-IN-CHARGE /OWNER for the purpose of verifying any CONTRACTOR’s claim.

56.9 DISCHARGE OF OWNER’S LIABILITY

56.9.1 The acceptance by the CONTRACTOR of any amount paid by the OWNER to CONTRACTOR in respect of the Final Bill of the CONTRACTOR in settlement of all said dues to the CONTRACTOR under the Final Bill shall, without prejudice to the claims of the CONTRACTOR included in the Final Bill in accordance with the provisions of clause 56.4.2 of GCC, be deemed to be in full and final settlement of all such dues to the CONTRACTOR notwithstanding any qualifying remarks, protest or condition imposed or purported to be imposed by the CONTRACTOR related to the acceptance of such payment, with the intent that upon acceptance by the CONTRACTOR of any payment made as aforesaid, the CONTRACT (including the arbitration clause) shall stand discharged and extinguished insofar as relates to and/or concerns the entitlements of the CONTRACTOR under the CONTRACT except for the CONTRACTOR’s right, if any, to receive payment in respect of his notified claims included in his Final Bill and the right to receive payment of the unadjusted balance of the Security Deposit in accordance with the provisions of Clause 56.10.3 on successful completion of the DEFECT LIABILITY
PERIOD. But nothing herein stated shall affect the CONTRACTOR’s undischarged liabilities and obligations under the CONTRACT.

56.9.2 The acceptance by the CONTRACTOR of any amount paid by the OWNER to the CONTRACTOR in respect of the notified claims of the CONTRACTOR included in the Final Bill, in settlement of the claims of the CONTRACTOR, shall be deemed to be in full and final settlement of all claims of the CONTRACTOR and, the CONTRACT shall stand discharged and extinguished insofar as relates to and/or concerns the claims of the CONTRACTOR except for the CONTRACTOR’s rights to receive payments of the unadjusted balance, if any, of the security deposit in accordance with clause 56.10.3.0 hereof on successful completion of the DEFECT LIABILITY PERIOD. But nothing herein stated shall affect the CONTRACTOR’s undischarged liabilities and obligations under the CONTRACT.

56.9.3 Notwithstanding anything provided in Clause 56.9.1 and/or Clause 56.9.2, the CONTRACTOR shall be and remain liable for defects in terms of DEFECT LIABILITY PERIOD and associated clause thereunder and for any indemnity to the OWNER in terms of Clause 56.10.2 and shall be and remain entitled to receive the unadjusted balance of the Security Deposit remaining in the hands of the OWNER in terms of Clause 56.10.3 and associated clauses thereunder.

56.10.0 FINAL ACCEPTANCE CERTIFICATE

56.10.1 Forthwith on the CONTRACTOR’s application made after the expiry of DEFECT LIABILITY PERIOD provided and associated clauses thereunder and satisfaction of all liabilities of the CONTRACTOR in respect thereof, the ENGINEER-IN-CHARGE shall issue a FINAL ACCEPTANCE CERTIFICATE to the CONTRACTOR Certifying that the CONTRACTOR has performed his obligations in respect of the DEFECT LIABILITY PERIOD and associated clauses thereunder, and until issue of such FINAL ACCEPTANCE CERTIFICATE, the CONTRACTOR shall be deemed not to have performed such liabilities notwithstanding issue of the PRELIMINARY ACCEPTANCE CERTIFICATE or payment of the Final Bill by the OWNER.

In the event that OWNER fails to issue the FINAL ACCEPTANCE CERTIFICATE, or fails to notify CONTRACTOR the reason for not issuing said certificate of acceptance, within a period of 60 days from CONTRACTOR’s application, the FINAL ACCEPTANCE CERTIFICATE shall be deemed as issued by OWNER for all contractual purposes.

56.10.2 Upon application for the FINAL ACCEPTANCE CERTIFICATE, the CONTRACTOR shall:

(i) Be deemed to have warranted that it had been fully paid and satisfied all claims for or arising out of the WORK, labour, MATERIALS, supplies and EQUIPMENT used in or connected with the CONTRACT and all other liabilities whatsoever touching or affecting the CONTRACT, or its performance, including in relation to SUB-CONTRACTORS and suppliers, and

(ii) To have undertaken to indemnify and keep indemnified the OWNER from and against all claims, demands, debts, liens, obligations and liabilities whatsoever arising there from or relating thereto.
56.10.2.1 Upon issue of the FINAL ACCEPTANCE CERTIFICATE, the CONTRACTOR shall be
deemed to have released, acquitted and discharged the OWNER from and against all
claims (known or unknown), liens, demands or causes of action of any kind whatsoever
arising out of or relating to the CONTRACT or otherwise howsoever touching or affecting
the same.

56.10.3 Forthwith on application made by the CONTRACTOR in this behalf accompanied by the
FINAL ACCEPTANCE CERTIFICATE, or within 84 (Eighty Four) days of the OWNER
passing the CONTRACTOR’s Final Bill, whichever shall be later, the OWNER shall
cancel and return to the CONTRACTOR all previous Bank Guarantees remaining
unutilised in the hands of the OWNER, and upon such cancellation and return, the
OWNER shall stand discharged of all obligations/ liabilities under the CONTRACT
provided that the cancellation and return of any Bank Guarantee(s) furnished by the
CONTRACTOR as and by way of security deposit shall be subject to the CONTRACTOR
replacing such Bank Guarantee(s) with a Bank Guarantee from OWNER’s approved list
of banks in a format acceptable to the OWNER covering 10% (ten percent) of the value
(or as determined by the OWNER) of equipments/works replaced or repaired during the
DEFECT LIABILITY PERIOD for the unexpired term of extended defect liability period in
respect thereof plus a 6 (six) months period. The claims or demands made during such
additional 6 months period shall refer to events which has occurred before the expiry of
the DEFECT LIABILITY PERIOD.

56.11 CLAIMS OF OWNER

56.11.1 The release/payment of any unadjusted balance of the Security Deposit (furnished in the
form of a Bank Guarantee or otherwise) by the OWNER to the CONTRACTOR as
aforesaid or otherwise shall not be deemed or treated as a waiver of any right(s) or
claim(s) of the OWNER existing before the issuance of the FINAL ACCEPTANCE
CERTIFICATE or shall not stop or prevent the OWNER from thereafter making or
enforcing any claim or any rights existing before the issuance of the FINAL
ACCEPTANCE CERTIFICATE against the CONTRACTOR with the intent that the claims
of the OWNER, against the CONTRACTOR shall continue to survive and shall not get
extinguished notwithstanding the issue of FINAL ACCEPTANCE CERTIFICATE and/or
the release of Security Deposit to the CONTRACTOR.

57.0 UNDERGROUND OBSTRUCTIONS

The soil investigation report furnished in the NIT is indicative only and is enclosed purely
for information/guidance purpose to the bidders. The contractor shall carry out its own
detailed soil investigation for the proposed plant. Design of the foundation system of the
plant shall be based, only on the site specific report. Nothing extra shall be paid in case of
any variation arising out of the soil report conducted report conducted by the bidders and
the data given in the tender. In the event, CONTRACTOR encounters any underground
obstructions, the same shall be removed by CONTRACTOR without any extra cost
implications to the OWNER.

In the event, CONTRACTOR encounters any underground obstruction which entails cost
implication to the CONTRACTOR, the OWNER shall consider to compensate the
CONTRACTOR reasonable cost compensation and/or time extension, depending on
merit of the case after mutual discussion. The decision of the ENGINEER-IN-CHARGE in this regard shall be in writing and shall be final and binding upon the CONTRACTOR. It is clarified that in case the CONTRACTOR disagrees with the decision of ENGINEER-IN-CHARGE, the dispute shall be settled as per the provision of clause 39 of GCC.

57.1 ARTICLES OF VALUE FOUND:

All gold, silver and other minerals of any description and all precious stones, coins, treasure relics, antiquities and other similar things which shall be found in, under or upon the SITE, shall be the property of the OWNER and the CONTRACTOR shall duly preserve the same to the satisfaction of the ENGINEER-IN-CHARGE and shall from time to time deliver the same to such person or persons indicated by the OWNER.

58.0 REGISTRATION OF THE CONTRACTOR WITH STATUTORY AUTHORITIES

58.1 Within 30 days of execution of the CONTRACT, the CONTRACTOR shall, insofar as necessary, register itself and the CONTRACT at their own cost with the Reserve Bank of India, Income Tax, Sales Tax and/or any other applicable statutory authorities as required under the rules and regulations governing in India. The CONTRACT PRICE shall be deemed to include all costs towards the same. A copy of all documents related to all such registration shall be submitted to OWNER for record.

58.2 Immediately after notification of the Acceptance of Bid, the foreign CONTRACTOR shall obtain permission for opening of their office(s) in India from the Reserve Bank of India, and shall obtain Income Tax clearance from Indian Income Tax authorities. Among other formalities, these will be required by the OWNER to release any payment due to the CONTRACTOR.

59.0 STATUTORY APPROVALS

59.1 Unless otherwise specified in Bidding Documents, it shall be the CONTRACTOR's sole responsibility to obtain all approvals from any authority (except for environment clearance and Consent to Establish/Operate, However the data and information required for the same shall be made available by the LSTK contractor) required under any statute, rule or regulation of the Central or State Government concerned with the performance of the CONTRACT and/or the contractual Work. The application on behalf of the OWNER for submission to relevant authorities along with copies of required certificates complete in all respects shall be prepared and submitted by the CONTRACTOR well ahead of time so that the actual construction/COMMISSIONING of the WORKS is not delayed for want of the APPROVAL/inspection by the concerned authorities. The CONTRACTOR shall arrange for the inspection of the works by the authorities and will undertake necessary coordination and liaison required and shall not be entitled to any extension of time for any delay in obtaining such approval. All statutory fees shall be paid by the CONTRACTOR and the same shall be reimbursed by the OWNER upon production of documentary evidence by the CONTRACTOR.

59.2 Any deficiency(ies) as pointed out by any such authority shall be rectified by the CONTRACTOR within the scope of relative supply and/or WORK at no extra cost to the OWNER. The inspection and acceptance of the WORKS by such authorities shall,
however, not absolve the CONTRACTOR from any of its responsibilities under this CONTRACT.

59.3 No extension of time shall be granted for meeting the requirement and/or obtaining APPROVAL of statutory authorities.

60.0 UTILISATION OF LOCAL RESOURCES

60.1 The CONTRACTOR shall ascertain the availability of local SUB-CONTRACTORS and skilled/unskilled manpower and engage them to the extent possible for performance of the WORKS.

60.2 The CONTRACTOR shall not recruit personnel of any category from among those who are already employed by the other agencies working at the site, but shall make maximum use of local labour available.

61.0 FUEL REQUIREMENT OF WORKERS

The CONTRACTOR shall be responsible to arrange for the fuel requirement of his workers and staff without resorting to cutting of trees and shrubs. Cutting of trees and shrubs is strictly prohibited for this purpose. The CONTRACTOR shall abide by the conditions put forth by the Environmental Clearance for the SITE as regards to construction workers.

62.0 SURPLUS MATERIAL

Notwithstanding anything provided elsewhere, all surplus materials shall be dealt as follows:

62.1 Any balance Indigenous/imported surplus MATERIALS including scrap shall belong to the CONTRACTOR upon completion of the WORKS and will be allowed to be taken back by CONTRACTOR after compliance of statutory formalities.

62.2 For taking out balance indigenous/imported surplus MATERIALS as mentioned above upon the completion of the project, the CONTRACTOR shall have to furnish proof of entry and ownership of such MATERIALS inside the SITE, certification of ENGINEER-IN-CHARGE and OWNER in this regard.

62.3 In case of applicability of concessional custom duty. All imported surplus materials other than CONSTRUCTION EQUIPMENT which is brought to the SITE shall be the OWNER's property and shall be returned by the CONTRACTOR to the OWNER's designated stores. All such materials shall be subject to reconciliation and a proper accounting procedure shall be developed and strictly followed by the CONTRACTOR recorded in the inspection reports, proforma of which will be approved by the ENGINEER-IN-CHARGE. These reports shall form part of the completion DOCUMENTS. Inspection and acceptance of the WORK shall not relieve the CONTRACTOR from any of his responsibilities under this CONTRACT. However, indigenous Surplus Material as certified by the OWNER will be allowed to be taken back by Contractor after compliance of statutory formalities.
63.0 COORDINATION WITH OTHER AGENCIES

63.1 CONTRACTOR shall be responsible for proper coordination with other agencies operating at the site so that WORK may be carried out concurrently, without any hindrance to others. The ENGINEER-IN-CHARGE shall resolve disputes, if any, in this regard, and his decision shall be final and binding on the CONTRACTOR.

63.2 If and when required for the coordination of the WORKS with other agencies involved at SITE, the CONTRACTOR shall within the scope of work, re-route and/or prepare approaches and working areas as may be necessary.

64.0 ERECTION OF EQUIPMENT

All erection shall be carried out by deploying a crane(s) of suitable capacity. Erection by derrick shall not be permissible. The CONTRACTOR shall submit erection schemes for erection of critical equipment to ENGINEER-IN-CHARGE for his APPROVAL. No EQUIPMENT shall be erected in the absence of an approved erection scheme for such EQUIPMENT.

The quoted rates of the CONTRACTOR shall be deemed to include load testing of the crane as required to establish the lifting capacity of the crane.

65.0 ELECTRICAL CONTRACTORS LICENCE

65.1 The CONTRACTOR or its nominated SUB-CONTRACTOR(s), as the case may be, shall have a valid electrical contractor's license for working in the State in which the job site is located. The CONTRACTOR shall furnish a copy of the same to ENGINEER-IN-CHARGE before commencement of any electrical work or work pertaining to Electrical System.

65.2 No electrical work or work pertaining to electrical system(s) shall be permitted to be executed without a valid Electrical Contractors License being produced by the CONTRACTOR or SUB-CONTRACTOR, as the case may be, intending to execute the WORK.

66.0 RENTS & ROYALTIES

Unless otherwise specified, the CONTRACTOR shall pay all tonnage and other royalties, rents and other payments or compensation (if any) for getting stone, sand, gravel, clay, bricks or other materials required for the WORKS or any temporary works.

67.0 GOVERNMENT OF INDIA NOT LIABLE

It is expressly understood and agreed by and between the CONTRACTOR and the OWNER that the OWNER is entering into this agreement solely on its own behalf and not on behalf of any other person or entity. In particular, it is expressly understood and agreed that the Government of India is not a party to this agreement and has no liabilities, obligations or rights thereunder. It is expressly understood and agreed that the OWNER is an independent legal entity with power and authority to enter into contracts, solely in its own behalf under the applicable laws of India and general principles of Contract. The CONTRACTOR expressly agrees, acknowledges and understands that the OWNER is not an agent, representative or delegate of the Government of India. It is further understood and agreed that the Government of India is not and shall not be liable for any
acts, omissions commissions, breaches or other wrongs arising out of the CONTRACT. Accordingly, CONTRACTOR hereby expressly waives, releases and foregoes any and all actions or claims, including cross claims or counter claims against the Government of India arising out of this CONTRACT and covenants not to sue the Government of India on any matter, claim, and cause of action or thing whatsoever arising of or under this CONTRACT.

68.0 SITE CLEANING

The CONTRACTOR shall take care to keep clean the job site at all times for easy access to the job site and also from the safety point of view in accordance with the CONTRACT requirements.

69.0 ACCESS TO SITE

69.1 The CONTRACTOR shall at his own cost and initiative arrange for and provide any access to the work area and stringing or other yards for labour, EQUIPMENT and MATERIAL as may be necessary for any cause in addition to the ingress and egress available. Any arrangements in respect thereof as may be entered into by the CONTRACTOR with any person interested in the land through which access is sought, shall be in writing and a copy of the writing (certified by or on behalf of the CONTRACTOR to be true copy thereof) shall forthwith be lodged with the OWNER. Such a writing shall specifically stipulate that the OWNER shall not be responsible for any claims under the CONTRACT or for any damage, loss or injury to the land or any material, item or thing thereon or in, and the CONTRACTOR shall keep the OWNER indemnified from and against any claim, action or proceedings in respect thereof.

69.2 The CONTRACTOR shall at his own cost and initiative arrange for and obtain all necessary permissions, permits, consents and licenses as may be necessary to transport the MATERIALS, tools, EQUIPMENT, machinery and labour along or across any highway, roadway, or other way, or railway, tramway, bridge, dyke, dam or embankment, or lake, pond, canal, river, state terminal toll octroi, or other line, border or barrier. Traffic study if required, shall be carried out by CONTRACTOR independently without any liability on OWNER.

70.0 INDEPENDENT CONTRACTOR

70.1 OWNER shall have the right to instruct and direct CONTRACTOR, as to the results to be obtained under the CONTRACT, and shall be entitled to ascertain whether the WORK is carried out in accordance with the requirements of the CONTRACT, including the right to inspect the WORK at all stages of its performance. Such instructions direction and/or inspection by OWNER shall not relieve CONTRACTOR of his obligation, duties or liabilities under the CONTRACT.

70.2 Neither CONTRACTOR nor any SUB-CONTRACTOR nor the employees, agents or representative of either shall be deemed to be employees, agents or representative of the OWNER in the performance of the CONTRACTOR obligations here under, unless otherwise specified in the CONTRACT.

71.0 CONTRACTOR shall indemnify and hold harmless OWNER for any claim brought by SUBCONTRACTOR against OWNER in relation to CONTRACTOR’s payment obligations.
for the relevant purchase orders and sub-contracts.

71.1 CONTRACTOR agrees that he shall furnish to OWNER, if requested, satisfactory evidence that all SUB-CONTRACTORS, including vendor to CONTRACTOR have been paid on the time and in full for work done or good supplies in connection with the performance of the WORK.

71.2 If such satisfactory evidence is not supplied then the OWNER shall not be bound to make any further payment to CONTRACTOR for that part of work until it is supplies.

71.3 CONTRACTOR shall notify OWNER of any dispute of any kind between CONTRACTOR and any of his SUB-CONTRACTOR or vendors stating the nature of dispute, the amount of any payment which is being withheld by CONTRACTOR, the reasons thereof and the CONTRACTOR plan settle the dispute.

72.0 ORDER OF WORKS / PERMISSION / RIGHT OF ENTRY / CARE OF EXISTING SERVICES

CONTRACTOR is required to submit to OWNER the various details with respect to their personnel(s) to be deputed for the execution of WORK such as name(s), nationality and passport details in case of Foreign Nationals (Passport No., Date of Issue, Date of Expiry etc.). These details are required for granting permission to enter and work in the existing fertilizer complex. The OWNER reserves the right to declare any person(s) as non grata. No claim whatsoever shall be entertained by OWNER on this account.

OWNER shall have the right to object to any Representative or personnel deputed to India by CONTRACTOR for execution of WORK or in connection with WORK, due to their misconduct or breach of law and regulation or who are found to be incompetent or negligent. CONTRACTOR shall remove such persons from SITE forthwith and take immediate action for replacement at no cost to OWNER.

73.0 GIFTS, COMMISSIONS, ETC.

Any gift, commission or advantage given, promised or offered by or on behalf of the CONTRACTOR or his partner, agent, officers, directors, employee or servant or anyone on his or their behalf in relation to the obtaining or to the execution of this or any other contract with the OWNER, shall in addition to any criminal liability which it may incur, subject the CONTRACTOR to the cancellation of this and all other contracts and also the payment of any loss or damage to the OWNER resulting from any cancellation. The OWNER shall then be entitled to deduct the amounts so payable from any monies otherwise due to the CONTRACTOR under the CONTRACT.

74.0 LABOUR LAWS- PF, EPF AND ESI

74.1 The CONTRACTOR shall obtain necessary license from the Licensing Authority under the Contract Labour (Regulation & Abolition) Act 1970 and the Central Rules framed thereunder and produce the same to the ENGINEER-IN-CHARGE before start of WORK.

74.2 The CONTRACTOR shall not undertake or execute or permit any other agency or SUB-CONTRACTOR to undertake or execute any work on the CONTRACTOR’S behalf
through contract labour except under and in accordance with the license issued in that behalf by the Licensing Officer or other authority prescribed under the Factories Act or the contract labour (Regulation & Abolition) Act 1970 or their applicable lay, rule or regulation, if applicable.

74.3 The provision of EPF & MP Act, 1952 and Rules scheme there under shall be applicable to the CONTRACTOR and the employees engaged by him for the WORK. The CONTRACTOR shall furnish the code number allotted by the RPFC Authority, to the ENGINEER-IN-CHARGE before commencing the WORK.

74.4 The CONTRACTOR shall be exclusively responsible for any delay in commencing the work on account of delay in obtaining a license under clause 74.1 above or in obtaining the code number under clause 74.3 above and the same shall not constitute a ground for extension of time for any purpose.

74.5 The CONTRACTOR shall enforce the provisions of ESI Act and Scheme framed from time to time there under with regard to all his employees involved in the performance of the CONTRACT and shall deduct employee's contribution from the wages of each of the employees and shall deposit the same together with employer's contribution of such total wages payable to the employees in the appropriate account.

74.6 All liabilities like salaries, wages and other statutory obligations in respect of the persons engaged by the CONTRACTOR shall be borne by the CONTRACTOR during the period of agreement. In view of the provisions of the ESI Act, PF and EPF Act and other Acts, as may be applicable to OWNER, the CONTRACTOR shall take necessary steps to cover its employees under the said enactments and shall submit proof of such compliance to ENGINEER-IN-CHARGE periodically or at any date upon such request, as may be made by ENGINEER-IN-CHARGE to the CONTRACTOR. In the event of non-compliance with the statute or the provisions thereof, referred to above, it shall be open to OWNER to withhold such amount as in its opinion is due and payable by the CONTRACTOR in respect of its employees from and out of dues, payable by OWNER to the CONTRACTOR and such due shall be held by OWNER with it until proof is submitted by the CONTRACTOR to OWNER indicating compliance with such statutes within reasonable time, failing which OWNER shall deposit such amounts with the authorities concerned on behalf of the CONTRACTOR and inform the CONTRACTOR of such deposit or deposits.

75.0 GENERAL PROVISIONS

75.1.0 Confidential Information

75.1.1 Non-disclosure

75.1.1.1 Each party agrees to hold in confidence any information imparted to it or in the case of CONTRACTOR, to any of its SUB-CONTRACTOR / VENDOR, by the other Party which pertains to that other party’s business activity in any manner, and which is not be subject of general public knowledge, including, without limitation, proprietary processes, technical information and know-how, information concerning other projects, management policies, economic policies, financial and other data and the like. The preceding non-disclosure requirements shall not apply to:
i) Information furnished without restriction by the other Party prior to the date hereof

ii) Information in the public domain; or

iii) Information obtained by a Party from a third Person not under obligation of non-disclosure to the other party.

(iv) Information required to be disclosed in pursuance of an order, judgment, decree of the Court, Tribunal or Statutory Authority.

75.1.2 Disclosure to Govt. Agency

75.1.2.1 Either Party may disclose any such information to the extent that such Party is required by any Government Agency to make such disclosure. In addition, OWNER may disclose such information to the extent that such disclosure is required by any Lender / Lender’s Representative, etc. provided that such Lenders signed a confidentiality agreement containing confidentiality and limited use obligations not less stringent than those accepted by OWNER under the CONTRACT and License Agreement and such parties are not competitor of CONTRACTOR or its Licensors.

75.1.3 Upon completion of the Works or in the event of termination pursuant to the provisions of the CONTRACT, CONTRACTOR shall immediately return to the OWNER all drawings, plans, specifications and other documents supplied to the CONTRACTOR by or on behalf of the OWNER or prepared by the CONTRACTOR solely for the purpose of the performance of the WORKS, including all copies made thereof by the CONTRACTOR.

75.1.4 This clause shall survive and remain in full force for a period of ten years following the issue of FINAL ACCEPTANCE CERTIFICATE.

75.2.0 Deleted

75.3.0 Recovery of Sums / Dues

75.3.1 All costs, damages or expenses which OWNER may have incurred, for which CONTRACTOR is liable under CONTRACT, shall be notified to CONTRACTOR and shall be recovered by OWNER from any payment due to or becoming due to CONTRACTOR under this CONTRACT or other CONTRACT and/or shall be recovered by action at law or otherwise. If the payment due to CONTRACTOR is not sufficient for recovery of the said sums/dues, CONTRACTOR shall pay immediately to OWNER such sums/dues or the balance sums/dues on demand.

75.3.2 All MUTUALLY AGREED DAMAGES applicable and to be recovered from CONTRACTOR under CONTRACT, shall be recovered by OWNER from any payment due to or becoming due to CONTRACTOR under this CONTRACT or other CONTRACT and/or shall be recovered by action at law or otherwise. If the payment due to CONTRACTOR is not sufficient for recovery of the said MUTUALLY AGREED
DAMAGES, CONTRACTOR shall pay immediately to OWNER such MUTUALLY AGREED DAMAGES, or the balance MAD on demand.

75.3.3 For avoidance of doubt all the rights and remedies of OWNER/ CONTRACTOR and liabilities of the CONTRACTOR/ OWNER as set out in the CONTRACT shall be to the exclusion of any other rights, remedies or liabilities available at law.

75.4.0 Payments etc. not to affect rights of OWNER

No sum paid on account by OWNER nor any extension of the date for completion granted by OWNER shall affect or prejudice the rights of OWNER against CONTRACTOR or relieve CONTRACTOR of its obligation for the faithful performance of CONTRACT.

75.5.0 Cut-Off Dates

No claims or correspondence on claims on this CONTRACT shall be entertained by either parties after 6 months after expiry of the Performance Bank Guarantee, unless specified otherwise in CONTRACT.

75.6.0 Paragraph Heading

The paragraph heading in those conditions shall not affect the construction thereof.

75.7.0 Site Working and Safety Conditions

CONTRACTOR shall follow the SITE working and safety conditions enclosed as Section VI-14.

75.8.0 Miscellaneous

75.8.1 No CONTRACT or understanding in any way modifying the conditions of CONTRACT shall be binding upon either parties hereto unless made in writing and approved by both parties.

75.8.2 Without prejudice to FORCE MAJEURE, CONTRACTOR shall, during inclement weather, carry out WORK in accordance with CONTRACT and CONTRACTOR shall not be entitled to any additional payment over and above the fees payable under CONTRACT by reason of its being unable to carry out WORK owing to inclement weather.

75.9.0 Member of OWNER not individually liable

No Director, or official or employee of the OWNER/ PMC shall in any way be personally bound or liable for the acts or obligations of the OWNER under the CONTRACT or answerable for any default or omission in the observance or performance of any of the acts, matters or things which are herein contained.

76.0 Implementation of Apprentices act 1961:
The CONTRACTOR shall comply with the provisions of the Apprentices Act, 1961 and the Rules and Orders issued thereunder from time to time. If he fails to do so, his failure will be a breach of the CONTRACT and the ENGINEER-IN-CHARGE may, at his discretion, cancel the CONTRACT. The CONTRACTOR shall also be liable for any pecuniary liability arising on account of any violation by him of the provisions, of the Act.

77.0 Change in constitution

Where the CONTRACTOR is a partnership firm, the prior approval of the OWNER shall be obtained in writing, before any change is made in the constitution of the firm. Where the CONTRACTOR is an individual or a Hindu undivided family business concern, such approval as aforesaid shall, likewise be obtained before such CONTRACTOR enters into any agreement with other parties, where under, the reconstituted firm would have the right to carry out the work hereby undertaken by the CONTRACTOR. In either case if prior approval as aforesaid is not obtained, the CONTRACT shall be deemed to have been allotted in contravention of clause 12 of GCC and the same action may be taken and the same consequence shall ensure as provided in the said clause.

78.0 Access by Road:

CONTRACTOR, if necessary, shall build other temporary access roads to the actual site of construction for his own work at his own cost. The CONTRACTOR shall be required to permit the use of the roads so constructed by him for vehicles of any other parties who may be engaged on the project site. The CONTRACTOR shall also facilitate the construction of the permanent roads should the construction there of start while he is engaged on this work. He shall make allowance in his tender for any inconvenience he anticipates on such account. Non-availability of access roads, railway siding and railway wagons for the use of the CONTRACTOR shall in no case condone any delay in the execution of WORK nor be the cause for any claim for compensation against the OWNER.

79.0 Members of the OWNER not individually liable:

No Director, or official or employee of the OWNER/ PMC shall in any way be personally bound or liable for the acts or obligations of the OWNER under the CONTRACT or answerable for any default or omission in the observance or performance of any of the acts, matters or things which are herein contained.

80.0 OWNER not bound by personal representations:

The CONTRACTOR shall not be entitled to any increase on the scheduled rates or any other right or claim whatsoever by reason of any representation, explanation statement or alleged representation, promise or guarantees given or alleged to have been given to him by any person.

81.0 Land for Contractor's Field Office, Godown and Workshop:

The OWNER will, at his own discretion and convenience and for the duration of the execution of the work make available near the site, land for construction of CONTRACTOR's Temporary Field Office, godowns workshops and assembly yard required for the execution of the CONTRACT. The CONTRACTOR shall at his own cost construct all these temporary buildings and provide suitable water supply and sanitary arrangement and get the same approved by the ENGINEER-IN-CHARGE. On completion of the works undertaken by the CONTRACTOR, he shall remove all temporary works erected by him and have the SITE cleaned as directed by ENGINEER-IN-CHARGE. If the
CONTRACTOR shall fail to comply with these requirements, the ENGINEER-IN-CHARGE may at the expenses of the CONTRACTOR remove such surplus, and rubbish materials and dispose-off the same as he deems fit and get the site cleared as aforesaid; and CONTRACTOR shall forthwith pay the amount of all expenses so incurred and shall have no claim in respect of any such surplus materials disposed off as aforesaid. But the OWNER reserves the right to ask the CONTRACTOR any time during the pendency of the CONTRACT to vacate the land by giving 7 days' notice on security reasons or on national interest or otherwise. Rent may be charged for the land so occupied from contractor by the OWNER. The CONTRACTOR shall put up temporary structures as required by them for their office, fabrication shop and construction stores only in the area allocated to them on the project site by the OWNER or his authorized representative. No tea stalls/canteens should be put up or allowed to be put up by any CONTRACTOR in the allotted land or complex area without written permission of the OWNER. Un-authorized buildings, constructions or structures should not be put up by the CONTRACTOR anywhere on the project site. For uninterrupted fabrication work, the CONTRACTOR shall put up temporary covered structures at his cost within Area in the location allocated to them in the project site by the OWNER or his authorised representative. No person except for authorized watchman shall be allowed to stay in the plant area/CONTRACTOR's area after completion of the day's job without prior written permission from ENGINEER-IN-CHARGE.

82.0 ROUNDOFF OF AMOUNTS:
In calculating the amount of each item due to the CONTRACTOR in every certificate prepared for payment, sum of less than 50 paise shall be omitted and the total amount on each certificate shall be rounded off to the nearest rupees, i.e., sum of less than 50 paise shall be omitted and sums of 50 paise and more upto one rupee shall be reckoned as one rupee.

83.0 ARTICLES OF VALUE FOUND:
All gold, silver and other minerals of any description and all precious stones, coins, treasure relics, antiquities and other similar things which shall be found in, under or upon the SITE, shall be the property of the OWNER and the CONTRACTOR shall duly preserve the same to the satisfaction of the ENGINEER-IN-CHARGE and shall from time to time deliver the same to such person or persons indicated by the OWNER.

84.0 WORK IN MONSOON AND DEWATERING
(i) Unless otherwise specified elsewhere in the tender, the execution of the WORK may entail working in the monsoon also. The CONTRACTOR must maintain a minimum labour force as may be required for the job and plan and execute the construction and erection according to the prescribed schedule. No extra rate will be considered for such work in monsoon.
(ii) During monsoon and other period, it shall be the responsibility of the CONTRACTOR to keep the construction work site free from water at his own cost

85.0 General conditions for construction and erection work:
(i) The working time at the site of work is 48 hours per week. Overtime work is permitted in cases of need and the OWNER will not compensate the same. Shift working at 2 or 3 shifts per day will become necessary and the CONTRACTOR should take this aspect into consideration for formulating his rates for quotation. No extra claims will be entertained by the OWNER on this account. No extra claims will be entertained by the OWNER on this account. For carrying out work beyond working hours the...
CONTRACTOR will approach the ENGINEER-IN-CHARGE or his authorized representative and obtain his prior written permission.

(ii) The CONTRACTOR must arrange for the placement of workers in such a way that the delayed completion of the WORK or any part thereof for any reason whatsoever will not affect their proper employment. The OWNER will not entertain any claim for idle time payment whatsoever.

(iii) The CONTRACTOR shall submit to the OWNER/ENGINEER-IN-CHARGE reports at regular intervals regarding the state and progress of WORK. The details and proforma of the report will mutually be agreed after the award of CONTRACT. The CONTRACTOR shall provide display board showing progress and labour strengths at worksite, as directed by the ENGINEER-IN-CHARGE.

86.0 **Action where no specification is issued:**

In case of any class of WORK for which there is no SPECIFICATION supplied by the OWNER as mentioned in the Tender Documents such WORK shall be carried out in accordance with Indian Standard Specifications and if the Indian Standard Specifications do not cover the same, the WORK should be carried out as per standard Engineering Practice subject to the approval of the ENGINEER-IN-CHARGE.

87.0 **Deleted**

88.0 **Deleted**

89.0 **CARE OF WORKS:**

i) From the commencement to completion of the WORK, the CONTRACTOR shall take full responsibility for the care for all works including all temporary works and in case any damages, loss or injury shall happen to the WORK or to any part thereof or to any temporary works from any cause whatsoever, shall at his own cost repair and make good the same so that at completion the WORK shall be in good order and in conformity in every respects with the requirement of the CONTRACT and the ENGINEER-IN-CHARGE’s instructions.

ii) **DEFECTS PRIOR TO TAKING OVER:** If at any time, before the WORK is taken over, the ENGINEER-IN-CHARGE shall: a) Claim that any works done or materials used by the CONTRACTOR or by any SUB-CONTRACTOR is defective or not in accordance with the CONTRACT, or that the works or any portion thereof are defective, or do not fulfill the requirements of CONTRACT (all such matters being hereinafter, called ‘Defects’ in this clause), and b) As soon as reasonably practicable, gives to the CONTRACTOR notice in writing of the said decision, specifying particulars of the defects alleged to exist or to have occurred, then the CONTRACTOR shall at his own expenses and with all speed make good the defects so specified. In case CONTRACTOR shall fail to do so, the OWNER may take, at the cost of the CONTRACTOR, such steps as may in all circumstances, be reasonable to make good such defects. The expenditure so incurred by the OWNER will be recovered from the amount due to the CONTRACTOR. The decision of the ENGINEER-IN-CHARGE with regard to the amount to be recovered from the CONTRACTOR will be final and binding on the CONTRACTOR. As soon as the WORK has been completed in accordance with the CONTRACT (except in minor respects that do not affect their use for the purpose for which they are intended and except for maintenance thereof provided in clause 3.0 (22) of General Conditions of
Contract) and have passed the tests on completion, the ENGINEER-IN-CHARGE shall issue a certificate (hereinafter called Completion Certificate) in which he shall certify the date on which the WORK have been so completed and have passed the said tests and the OWNER shall be deemed to have taken over the WORK on the date so certified. If the WORK has been divided into various groups in the CONTRACT, the OWNER shall be entitled to take over any group or groups before the other or others and there upon the ENGINEER-IN-CHARGE shall issue a Completion Certificate which will, however, be for such group or groups so taken over only. In such an event if the group /section/ part so taken over is related, to the integrated system of the work, notwithstanding date of grant of Completion Certificate for group/ section/ part.

iii) DEFECTS AFTER TAKING OVER: In order that the CONTRACTOR could obtain a COMPLETION CERTIFICATE he shall make good, with all possible speed, any defect arising from the defective materials supplied by the CONTRACTOR or workmanship or any act or omission of the CONTRACT or that may have been noticed or developed, after the works or groups of the works has been taken over, the period allowed for carrying out such WORK will be normally one month. If any defect be not remedied within a reasonable time, the OWNER may proceed to do the WORK at CONTRACTOR's risk and expense and deduct from the final bill such amount as may be decided by the OWNER. If by reason of any default on the part of the CONTRACTOR a COMPLETION CERTIFICATE has not been issued in respect of any portion of the WORK within one month after the date fixed by the CONTRACT for the completion of the WORK, the OWNER shall be at liberty to use the WORK or any portion thereof in respect of which a completion certificate has not been issued, provided that the WORK or the portion thereof so used as aforesaid shall be afforded reasonable opportunity for completing these works for the issue of Completion Certificate.

iv) COMPLETION CERTIFICATE’ wherever mentioned shall be read as ‘PRELIMINARY ACCEPTANCE CERTIFICATE’

90.0 Field Management & Controlling / Coordinating Authority:

i) The field management will be the responsibility of the ENGINEER-IN-CHARGE, who will be nominated by the OWNER. The ENGINEER-IN-CHARGE may also authorize his representatives to assist in performing his duties and functions.

ii) The ENGINEER-IN-CHARGE shall coordinate the works of various agencies engaged at site to ensure minimum disruption of work carried out by different agencies. It shall be the responsibility of the CONTRACTOR to plan and execute the work strictly in accordance with site instructions to avoid hindrance to the work being executed by other agencies.

91.0 Local Conditions:

i) It will be imperative on each tenderer to inform himself of all local conditions and factors which may have any effect on the execution of WORK covered under the Tender Document. In their own interest, the tenderer are requested to familiarize themselves with the Indian Income Tax Act 1961, Indian Companies Act 1956/2013, Indian Customs Act 1962 and other related Acts and Laws and Regulations of India with their latest amendments, as applicable. TFL shall not entertain any requests for clarifications from the tenderer regarding such local conditions.
ii) It must be understood and agreed that such factors have properly been investigated and considered while submitting the tender. No claim for financial or any other adjustments to VALUE OF CONTRACT, on lack of clarity of such factors shall be entertained.

92.0 Special Conditions of Contract:

i) Special Conditions of Contract (SCC) shall be read in conjunction with the General Conditions of Contract (GCC), specification of Work, Drawings and any other documents forming part of this CONTRACT wherever the context so requires.

ii) Notwithstanding the sub-division of the documents into these separate sections and volumes every part of each shall be deemed to be supplementary to and complementary of every other part and shall be read with and into the CONTRACT so far as it may be practicable to do so.

iii) Where any portion of the General Condition of Contract is repugnant to or at variance with any provisions of the Special Conditions of Contract, unless a different intention appears the provisions of the Special Conditions of Contract shall be deemed to over-ride the provisions of the General Conditions of Contract and shall to the extent of such repugnancy, or variations, prevail.

iv) Wherever it is mentioned in the specifications that the CONTRACTOR shall perform certain WORK or provide certain facilities, it is understood that the CONTRACTOR shall do so at his cost and the VALUE OF CONTRACT shall be deemed to have included cost of such performance and provisions, so mentioned.

v) The materials, design and workmanship shall satisfy the relevant INDIAN STANDARDS, the JOB SPECIFICATIONS contained herein and CODES referred to. Where the job specification stipulate requirements in addition to those contained in the standard codes and specifications, these additional requirements shall also be satisfied.

93.0 POWER OF ENTRY:

1) If the CONTRACTOR shall not commence the WORK in the manner previously described in the CONTRACT documents or if he shall at any time in the opinion of the ENGINEER-IN-CHARGE -

i) fail to carry out the WORK in conformity with the CONTRACT documents, or

ii) fail to carry out the WORK in accordance with the Time Schedule, or

iii) substantially suspend work or the WORK for a period of fourteen days without authority from the ENGINEER-IN-CHARGE, or

iv) fail to carry out and execute the WORK to the satisfaction of the ENGINEER-IN-CHARGE, or

v) fail to supply sufficient or suitable construction plant, temporary works, labour, materials or things, or

vi) Commit, suffer, or permit any other breach of any of the provisions of the CONTRACT on his part to be performed or observed or persist in any of the above mentioned breaches of the CONTRACT for fourteen days, after notice in writing shall have been given to the CONTRACTOR by the ENGINEER-IN-CHARGE requiring such breach to be remedied, or
vii) if the CONTRACTOR shall abandon the WORK, or

viii) if the CONTRACTOR during the continuance of the CONTRACT shall become bankrupt, make any arrangement or composition with his creditors, or permit any execution to be levied or go into liquidation whether compulsory or voluntary not being merely a voluntary liquidation for the purpose of amalgamation or reconstruction then in any such case, the OWNER shall have the power to enter upon the WORK and take possession thereof and of the materials, temporary WORK, construction plant, and stock thereon, and to revoke the CONTRACTOR's license to use the same, and to complete the WORK by his agents, other CONTRACTORS or workmen or to relate the same upon any terms and to such other person, firm or corporation as the OWNER in his absolute discretion may think proper to employ and for the purpose aforesaid to use or authorize the use of any materials, temporary work, CONSTRUCTION PLANT, and stock as aforesaid, without making payment or allowance to the CONTRACTOR for the said materials other than such as may be certified in writing by the ENGINEER-IN-CHARGE to be reasonable, and without making any payment or allowance to the CONTRACTOR for the use of the temporary said works, construction plant and stock or being liable for any loss or damage thereto, and if the OWNER shall by reason of his taking possession of the WORK or of the WORK being completed by other CONTRACTOR (due account being taken of any such extra work or works which may or be omitted) then the amount of such excess as certified by the ENGINEER-IN-CHARGE shall be deducted from any money which may be due for work done by the CONTRACTOR under the CONTRACT and not paid for. Any deficiency shall forthwith be made good and paid to the OWNER by the CONTRACTOR and the OWNER shall have power to sell in such manner and for such price as he may think fit all or any of the construction plant, materials etc. constructed by or belonging to and to recoup and retain the said deficiency or any part thereof out of proceeds of the sale.

94.0 LIENS:

1) If, at any time there should be evidence or any lien or claim for which the OWNER might have become liable and which is chargeable to the CONTRACTOR, the OWNER shall have the right to retain out of any payment then due or thereafter to become due an amount sufficient to completely indemnify the OWNER against such lien or claim and if such lien or claim be valid, the OWNER may pay and discharge the same and deduct the amount so paid from any money which may be or may become due and payable to the CONTRACTOR. If any lien or claim remain unsettled after all payments are made, the CONTRACTOR shall refund or pay to the OWNER all money that the latter may be compelled to pay in discharging such lien or claim including all costs and reasonable expenses. OWNER reserves the right to do the same.

2) The OWNER shall have lien on all materials, equipments including those brought by the CONTRACTOR for the purpose of erection, testing and commissioning of the WORK.

3) The final payment shall not become due until the CONTRACTOR delivers to the ENGINEER-IN-CHARGE a complete release or waiver of all liens arising or which may arise out of his agreement or receipt in full or certification by the CONTRACTOR in a form approved by ENGINEER-IN-CHARGE that all invoices for labour, materials, services have been paid in lien thereof and if required by the ENGINEER-IN-CHARGE in any case an affidavit that so far as the CONTRACTOR has knowledge
or information the releases and receipts include all the labour and material for which a lien could be filled.

4) CONTRACTOR will indemnify and hold the OWNER harmless, for a period of two years after the issue of FINAL ACCEPTANCE CERTIFICATE, from all liens and other encumbrances against the OWNER on account of debts or claims alleged to be due from the CONTRACTOR or his SUB-CONTRACTOR to any person including SUB-CONTRACTOR and on behalf of OWNER will defend at his own expense, any claim or litigation brought against the OWNER or the CONTRACTOR in connection therewith. CONTRACTOR shall defend or contest at his own expense any fresh claim or litigation by any person including his SUB-CONTRACTOR, till its satisfactory settlement even after the expiry of two years from the date of issue of FINAL CERTIFICATE.
SECTION – V

SPECIAL CONDITIONS OF CONTRACT
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The SPECIAL CONDITIONS OF CONTRACT shall be read in conjunction with the GENERAL CONDITIONS OF CONTRACT, specifications of work, DRAWINGS and any other document forming part of this CONTRACT wherever the context so requires.

Where any portion of the GENERAL CONDITIONS OF CONTRACT is repugnant to or at variance with any other provisions of the SPECIAL CONDITIONS OF CONTRACT, then unless a different intension appears, the SPECIAL CONDITIONS OF CONTRACT shall be deemed to over-ride the provisions of GENERAL CONDITIONS OF CONTRACT and shall prevail to the extent of such repugnancy or variations.

1.0 CONTRACTOR'S OBLIGATIONS
1.1.0 General Responsibility
1.1.1 The CONTRACTOR acknowledges that this CONTRACT is a Lumpsum turnkey contract and CONTRACTOR'S obligation hereunder, notwithstanding anything to the contrary contained herein, is to provide OWNER with fully operational PLANT, complete in all respects under and in accordance with the provision of CONTRACT, within the stipulated time and for the purpose designated herein by OWNER, and to do, furnish and provide everything necessary in connection therewith.

Without prejudice to the foregoing and except as otherwise expressly set forth in the CONTRACT as within the scope of OWNER's obligations under the CONTRACT, the CONTRACTOR shall perform or cause to be performed all WORK and services required in connection with the design, engineering, supply of equipment, procurement (including, without limitation, all transportation services in connection therewith), construction, erection, start-up, commissioning, testing including conducting of Performance Tests and other work and services upto the PRELIMINARY ACCEPTANCE OF PLANT by the OWNER including 6 months supervisory assistance after successful commissioning and in connection therewith provide all materials, equipment, machinery, tools, labour, transportation, administration and other services and items required to complete the PLANT in all respects upto the PRELIMINARY ACCEPTANCE OF PLANT and having the performance as guaranteed under the CONTRACT by the CONTRACTOR on a total, fixed price basis in accordance with this CONTRACT. The WORK shall, without prejudice to the generality of the foregoing or those enumerated in Clause 1.2.0 include but not be limited to the following:

(a) All engineering and design services including necessary investigation required for a completely engineered PLANT including necessary documentation;

(b) Provision of all equipment, systems, materials, processes, CONTRACTOR's EQUIPMENT, temporary works and all other items, whether of a temporary or permanent nature including those required for the design, erection, completion commissioning, conducting of PERFORMANCE GUARANTEE TEST RUN and remedying of DEFECTS during DEFECT LIABILITY PERIOD.
(c) Transportation from works, port of entry and import clearance and handling services in and into India and inland transportation from the relevant points of delivery of EQUIPMENT required in connection with the completion of the PLANT, and the performance of the other WORK.

(d) Project management.

(e) Receipt of EQUIPMENT at SITE including stores management.

(f) Construction infrastructure services, civil and structural construction; mechanical, electrical and instruments erection and installation services, inspection, testing and commissioning, and PERFORMANCE GUARANTEE TEST RUN before PRELIMINARY ACCEPTANCE of PLANT including all relevant applicable permits, with CONTRACTOR having responsibility for overall co-ordination of permits required by the OWNER and all training activities;

(g) Provision of all necessary superintendence, labour, construction fuels and construction chemicals, tools, supplies and other consumables and services;

Construction water (at one point within factory premises and CONTRACTOR to arrange the line upto their Battery Limit) and Construction Power (1 No. 11 kV feeder of 2 MVA at Existing Substation Near 132 kV Switchyard and CONTRACTOR to arrange tap off Power from this feeder) shall be provided within 6 months of issuance of FOA on chargeable basis (presently @ of Rs 4.50/m^3 for Construction Water and Rs 5.915/KWH for Construction Power. In case of any escalation by statutory authorities in the unit rates during execution of Contract, the same shall be borne by Contractor)

Raw Material and utilities as defined in Technical part of Section VI-2.0 of NIT and shall be made available to the LSTK CONTRACTOR at one point of Steam Generation Plant battery limit 2 months before scheduled Completion Period. However required utilities prior to this will be arranged by LSTK CONTRACTOR.

(h) Rectification of defects during DEFECT LIABILITY PERIOD.

1.1.2 CONTRACTOR shall provide services, for PLANT, in accordance with good engineering practice. CONTRACTOR shall provide services of engineers, designers, draftsmen, buyers, inspectors, expediters and other persons required for the performance of WORK pursuant to CONTRACT.

1.1.3 In the event that there is any item of EQUIPMENT or WORK of the type provided for in CONTRACT, which is not specifically mentioned in the specifications or drawings set out in FINAL PROPOSAL, but which is necessary (even though not mentioned in CONTRACT) for normal, safe and continuous operation of PLANT, , CONTRACTOR shall include such item of EQUIPMENT in the design and perform such items of WORK, for such EQUIPMENT or WORK free of cost to OWNER as if the same had been originally included in its Scope of Work/FINAL PROPOSAL.
1.1.4 Subject to prior consent of OWNER, CONTRACTOR may make use of the services of SUB-CONTRACTOR/ VENDOR (previously approved in writing by the OWNER) in accordance with the provisions in CONTRACT provided, however, the CONTRACTOR shall remain responsible and liable for the work done by such SUB-CONTRACTOR/vendor.

1.1.5 The CONTRACTOR shall be responsible for obtaining necessary approvals which are to be issued in the CONTRACTOR’S name from the various statutory authorities. All approvals/permissions other than Environment Clearance and Consent to Establish/Operate shall be obtained by the CONTRACTOR.

1.1.6 The CONTRACTOR shall provide necessary full technical assistance to OWNER including follow-up for obtaining the necessary approvals to be issued in the name of OWNER from the various statutory authorities.

1.1.7 The CONTRACTOR shall furnish CONTRACT SECURITY CUM PERFORMANCE BANK GUARANTEE as per the enclosed format in line with the provisions of bidding document.

1.1.8 The enumeration in subsequent Clauses of SPECIAL CONDITIONS OF CONTRACT, in GENERAL CONDITIONS OF CONTRACT and other documents of CONTRACT shall not in any manner limit the general scope of obligations and responsibilities of designing, engineering, procurement, supply, construction, commissioning and proving the performance guarantees of PLANT within the scope of CONTRACT.

1.2.0 CONTRACTOR’s Scope of Work

1.2.1 CONTRACTOR shall provide and be responsible for the tasks specified in this Clause under the following heads:

1.2.2 Deleted

1.2.3 Design & Engineering

1.2.3.1 CONTRACTOR shall provide all design and engineering services necessary for completion of the PLANTS in conformity with the CONTRACT and Good Engineering Practices and the NIT including but not limited to:

(a) Preparation of

- Project design book which shall form the basis of PLANT design;
- The conceptual design; and
- The engineering and design necessary to describe and detail the PLANT and the Project.
(b) Provision of criteria for the detailed design by other suppliers of equipment/system/structures for incorporation into the PLANTS.

(c) Preparation of design, engineering, drawings, plans, bill of material, schedule and estimates for the PLANT and the project and the performance by CONTRACTOR of its obligations hereunder so that the PLANT constructed and commissioned by the CONTRACTOR is capable of meeting the performance guarantees and will be such as could be legally, safely and reliably placed in commercial operation by the OWNER.

(d) CONTRACTOR shall perform the design and engineering for PLANT so that when constructed and commissioned, PLANT shall be capable of meeting the guarantees with respect to quality and quantity of products, consumption of raw materials and utilities, and Pollution Level as guaranteed under CONTRACT and shall be reliable and safe and operable in accordance with the sound engineering practice. CONTRACTOR shall ensure design capacity of all sections of PLANT in accordance with CONTRACTOR's experience vis-a-vis as indicated in this NIT and expertise for obtaining a full throughput under varying conditions within the limits specified in CONTRACT. PLANT shall be designed so as to be capable of producing at full plant capacity when operated as specified in CONTRACT. CONTRACTOR shall review the basic design conditions and other conditions furnished by OWNER in NIT. If CONTRACTOR observes any inconsistency or insufficiency in these data, CONTRACTOR shall bring to the notice of OWNER the same, before its use.

1.2.4 Deleted

1.2.5 Codes and Standards

1.2.5.1 The engineering shall be performed and EQUIPMENT shall be manufactured and supplied according to acceptable international standards, as specified in the Technical Specification/FINAL PROPOSAL, meeting safety and other requirements of various national/international Codes and Regulations being in force as on submission of the FINAL PROPOSAL. The design of PLANT shall be based on the criteria enumerated in CONTRACT. However, it shall be CONTRACTOR’s responsibility to follow all Indian Rules and Regulations as applicable.

CONTRACT shall comply with and shall cause the WORK and all components thereof (including, without limitation, the design and engineering of the PLANT) to comply with all APPLICABLE LAWS and APPLICABLE PERMITS as they may be in effect at the time of CONTRACTOR's performance under the CONTRACT.

The CONTRACTOR shall ensure that all actions on its behalf in connection with the WORKS shall be in compliance with applicable laws of India. The CONTRACTOR agrees to take all reasonable steps to ensure that Persons appointed by it in
connection with the WORK shall comply with the applicable laws/ regulations/ guidelines and obligations.

1.2.6 Drawings and Documents

1.2.6.1 CONTRACTOR shall prepare or secure and furnish to OWNER all data, specifications, drawings, plans and other documents as required/used for WORK as specified in Technical Specifications.

1.2.7 Owner's/PMC Review

1.2.7.1 ENGINEER-IN-CHARGE shall review all documents and give its comments to CONTRACTOR within 14 (Fourteen) working days from the date of receipt of the same. Review as aforesaid by OWNER/PMC and furnishing of comments by OWNER/PMC or the failure of OWNER/PMC to review or comment as aforesaid shall not relieve CONTRACTOR in any manner of its obligations including performance guarantees under this CONTRACT.

1.2.8 Procurement Services

1.2.8.1.1 As part of the WORK, CONTRACTOR shall procure and pay for, in CONTRACTOR's name as an independent contractor and not as agent for OWNER, all CONTRACTOR and SUB-CONTRACTOR'S labour, materials, equipment, supplies, soil, gravel and similar materials and manufacturing, fabrication and related services (whether on or off the PLANT Site) for construction and incorporation in the PLANT or which are otherwise required for completion of the WORK in accordance with the Specification and the CONTRACT and are not explicitly specified to be furnished by OWNER pursuant to the terms and provisions of the CONTRACT including FINAL PROPOSAL.

1.2.8.1.2 CONTRACTOR shall procure and provide all EQUIPMENT required for PLANT. EQUIPMENT procured shall be according to specifications as set forth in the CONTRACT, proven record of performance and with suitable delivery time to meet the COMPLETION PERIOD as given by CONTRACTOR. EQUIPMENT shall be procured from the vendor list agreed between CONTRACTOR and OWNER.

In connection with its procurement work, CONTRACTOR shall be responsible for the shipping, transportation and delivery of all items fabricated, manufactured, constructed or procured as set forth in the FINAL PROPOSAL and the CONTRACT. All such items and equipment, materials and supplies to be provided by the CONTRACTOR pursuant to the CONTRACT shall be new and of required quality, free from improper workmanship or defects and properly warranted or guaranteed in accordance with the CONTRACT. Any apparent omission or error in the equipment specifications will be corrected by the CONTRACTOR to the extent required by the CONTRACT including FINAL PROPOSAL.

1.2.8.2 Equipment
1.2.8.2.1 CONTRACTOR agrees that EQUIPMENT procured shall be strictly in accordance with the specifications as provided, however, that any apparent omission or error in the specifications will be corrected by CONTRACTOR if it is necessary for the functioning of EQUIPMENT. CONTRACTOR shall inform OWNER for such omission or error or ambiguity in the specifications and corrections made for the same.

1.2.8.2.2 Completeness of EQUIPMENT shall be the responsibility of CONTRACTOR. Any fittings, accessories, etc. which may not be specifically mentioned in Technical Specifications but which is required for the satisfactory functioning of EQUIPMENT and realization of PERFORMANCE GUARANTEES shall be provided by CONTRACTOR without any extra cost.

1.2.8.2.3 CONTRACTOR shall ensure that the modern practices in the manufacture of high grade EQUIPMENT are followed notwithstanding any omission in the specifications.

1.2.8.2.4 The supplies including fittings, accessories, etc. shall be in strict compliance to the applicable specifications/codes/standards. Components for which no relevant standards exist, the same shall be designed and manufactured as per good engineering practices.

1.2.8.2.5 The true intent and meaning of this Clause is that CONTRACTOR shall in all respects design, engineer, ensure quality of manufacture and supply EQUIPMENT in a thorough workman like manner, within prescribed time and in accordance with good engineering practice in order to enable proper operation of EQUIPMENT and PLANT.

1.2.8.2.6 CONTRACTOR shall furnish drawings and documents of EQUIPMENT as described in Technical part, Section VI. These documents shall include but not limited to technical documents, final drawings, preservation instructions, operation and maintenance manuals, test certificates, spare parts catalogues, etc. in a bound book for all rotating EQUIPMENT and in a folder for other EQUIPMENT, before despatch of EQUIPMENT under intimation to OWNER.

1.2.8.2.7 The documents, required for statutory approvals once submitted during construction period by CONTRACTOR shall be firm and final and not subject to subsequent changes unless such subsequent changes are approved by statutory agencies. CONTRACTOR shall be responsible for any payment of penalty as imposed by the Statutory Agencies consequent to furnishing of any incorrect data/drawings.

1.2.8.2.8 All dimensions and weights shall be in metric system.

1.2.8.2.9 EQUIPMENT to be supplied and WORK to be carried out under CONTRACT shall conform to and comply with the provision of relevant Regulations/Acts (or both) as may be applicable in the State of ODISHA and in India to the type of EQUIPMENT/ WORK carried out and necessary certificates shall be furnished.
1.2.8.2.10 CONTRACTOR shall provide cross sectional drawings wherever applicable to identify the spare part numbers and their location, e.g. the size of bearings/seals, their make and number shall be furnished.

1.2.8.3 CONTRACTOR shall furnish unpriced copy of Purchase Orders/Work Order/Contract for equipments and major items as per the list to be mutually agreed (including Priced copy of Purchase Orders/Work Order/Contract as required by the statutory authority) together with spares and special maintenance tools covering accurately all terms and conditions such as specifications requirements for quality, inspection, and test, warranties and guarantees, erection and commissioning assistance by vendor, delivery schedule, packing, transportation and insurance, and documentation.

1.2.8.4 CONTRACTOR shall arrange & furnish/provide to OWNER,

   a) Lubrication schedule from VENDOR,

   b) Mechanical specifications and equipment data sheets for review by OWNER for CRITICAL EQUIPMENT before manufacture is started,

   c) Shop fabrication drawings as made available by vendor,

   d) Characteristic curves for pumps and compressors, etc. as made available by vendor,

   e) Certified drawings including civil scope drawing and loading data, pertinent bulletin, installation, operation and maintenance manuals and test certificates as received from vendor,

   f) Final revised vendor’s drawings including one reproducible, as described in Technical Specifications, before PRILIMINARY ACCEPTANCE.

   g) Any other information as may be sought by OWNER.

Any changes necessary during commissioning period can be incorporated in the as-built drawing and will be submitted after PAC as per the mutually agreed schedule.

1.2.8.5 CONTRACTOR shall provide services of vendor’s specialist for installation and commissioning of EQUIPMENT whenever necessary.

1.2.8.6 Deleted

1.2.8.7 **Inspection, Expediting & Testing**

1.2.8.7.1 CONTRACTOR shall establish an inspection and expediting system and use its services for obtaining EQUIPMENT which conforms to the required technical and
quality specifications and delivery schedule according to Purchase Order. CONTRACTOR shall send copies of expediting and inspection reports regularly to OWNER. CONTRACTOR shall arrange Third Party Inspection and quality certification of EQUIPMENT, as described in FINAL PROPOSAL/CONTRACT.

Third party Inspection shall be carried by Llyods/BV/TUV/LRIS.

1.2.8.7.2 OWNER or its INSPECTOR shall have the right to inspect and/or to test EQUIPMENT to check its conformity to the specifications and as per approved QAP (Quality Assurance Plan). CONTRACTOR shall specify the inspections and tests to be carried out giving reference of applicable codes/standards and the location of inspection/test to OWNER. OWNER shall notify CONTRACTOR in writing the name of INSPECTOR retained for this purpose.

1.2.8.7.3 The inspection and tests may be conducted at the premises of CONTRACTOR or SUB-CONTRACTOR/vendor before delivery and/or at SITE. All reasonable facilities and assistance including access to all drawings and production data shall be furnished to INSPECTOR at no charge to OWNER.

1.2.8.7.4 Should any inspected or tested EQUIPMENT fail to conform to the specifications, OWNER may reject it and CONTRACTOR shall either replace the rejected EQUIPMENT or make all alterations necessary to meet specification requirements free of cost.

1.2.8.7.5 OWNER’s right to inspect and wherever necessary, comment about EQUIPMENT after its arrival at SITE or its participation in tests in respect of any EQUIPMENT shall in no way be limited or waived by reason of EQUIPMENT having previously been inspected, tested and passed by OWNER or INSPECTOR/representative prior to its shipment/despatch.

1.2.8.7.6 INSPECTOR shall follow the progress of the manufacture of EQUIPMENT under CONTRACT to ensure that the requirements outlined in CONTRACT are not being deviated from with respect to Schedule and Quality.

1.2.8.7.7 CONTRACTOR shall allow INSPECTOR to visit, during working hours, the workshops relevant to execution of CONTRACT during the contractual period and INSPECTOR will have the right to inspect EQUIPMENT at all stages of manufacture right from identification of material up to its shipment/despatch, to the extent that the delivery schedule shall not be delayed, with prior notice to CONTRACTOR in writing.

1.2.8.7.8 In order to enable INSPECTOR to obtain entry visa in time, CONTRACTOR shall notify OWNER two months before assembly, testing and packing of main EQUIPMENT and if requested assist INSPECTOR in getting visa in the shortest possible time.

1.2.8.7.9 CONTRACTOR shall place at the disposal of INSPECTOR free of charge all tools, instruments and other apparatus necessary for the inspection and/or testing of
EQUIPMENT. INSPECTOR is entitled to prohibit the use and despatch of EQUIPMENT that has failed to comply with the characteristics/specifications of EQUIPMENT during test and inspection.

1.2.8.7.10 CONTRACTOR shall ensure that the permission for inspection/test is granted by its SUB-CONTRACTOR/VENDOR.

1.2.8.7.11 In respect of the inspection, CONTRACTOR shall advise in writing of any delay in the programme at the earliest possible date, describing in detail what has caused the delay and the proposed corrective action.

1.2.8.7.12 All tests and trials in general of EQUIPMENT shall be witnessed by INSPECTOR. Therefore, CONTRACTOR shall confirm to OWNER by E-mail/fax about the exact date of inspection at least 15 DAYS in advance. CONTRACTOR shall specify the items and quantities ready for testing and indicate whether a Preliminary or Final Test is to be carried out.

1.2.8.7.13 On receipt of this notice, if OWNER decides to waive the right to witness the test, information shall be given to CONTRACTOR within 15 DAYS of receipt of the notice from CONTRACTOR and CONTRACTOR then shall have right to proceed with the inspection.

1.2.8.7.14 Any and all expenses incurred in connection with tests, preparation of reports and analysis made by qualified laboratories, necessary technical documents, testing documents and drawings shall be at CONTRACTOR's cost. Technical documents shall include the references and numbers of the standard used in the fabrication/construction and, wherever deemed practical by INSPECTOR. INSPECTOR shall attach importance to the views given by CONTRACTOR or its SUB-CONTRACTOR/VENDOR. Any and all expenses for boarding, lodging and airfare/rail fare incurred in connection with INSPECTOR shall be borne by OWNER.

1.2.8.7.15 Nothing in Clause -1.2.8.7.2 to 1.2.8.7.14 shall in any way relieve CONTRACTOR from any warranty or other obligations under this CONTRACT.

Not performing or failing to perform the inspection by OWNER hereunder shall not be a waiver of any of CONTRACTOR's obligations hereunder nor it be construed as an approval or acceptance of any of the WORK hereunder nor it shall absolve the CONTRACTOR in any way or manner of its liabilities, responsibilities and obligations under the CONTRACT.

1.2.8.7.16 Arrangements for all inspections required by Statutory Authorities and as specified in Technical Specifications shall be made by CONTRACTOR. Certain category of EQUIPMENT/piping fall under the jurisdiction of Indian Boiler Regulations (IBR), irrespective of the fact whether these are proprietary in nature or not, certification from an internationally recognised agency approved by IBR is considered necessary to enable local IBR authorities to allow their installation and operation. In such cases, inspection and certification from such authorities will also have to be arranged by
CONTRACTOR. CONTRACTOR shall also submit, as may be required by IBR authorities, necessary design calculations from respective fabricators and/or manufacturers of such EQUIPMENT.

1.2.8.7.17 Rejections, Removal of Rejected EQUIPMENT and Replacement

1.2.8.7.17.1 Preliminary inspection at SUB-CONTRACTOR’s / vendor’s works by INSPECTOR shall not prejudice OWNER for commenting on EQUIPMENT including its specifications on final inspection at SITE or claim under warranty provisions.

1.2.8.7.17.2 If EQUIPMENT is not of specification or fail to perform specified duties, OWNER shall be entitled to reject EQUIPMENT or part thereof and ask for modification, repair or free replacement within reasonable time subject to the relevant provisions in the CONTRACT.

1.2.8.7.17.3 In the event of such rejection, OWNER shall be entitled to use EQUIPMENT in a reasonable and proper manner for a time reasonably sufficient to enable it to obtain replacement, without any liability to CONTRACTOR. After free replacement of such rejected EQUIPMENT, the rejected equipment shall become the property of CONTRACTOR.

1.2.8.7.17.4 Nothing in this Clause shall be deemed to deprive OWNER and/or affect any of its rights under CONTRACT which it may otherwise have in respect of such defects or deficiencies or in any way relieve CONTRACTOR of its obligation under CONTRACT.

1.2.8.7.17.5 EQUIPMENT rejected by OWNER shall be removed by CONTRACTOR, within reasonable time, at its own cost after replacement of the said EQUIPMENT. OWNER shall in no way be responsible for any deterioration or damage to rejected EQUIPMENT under any circumstances whatsoever.

1.2.8.7.17.6 In case, the rejected EQUIPMENT is to be taken out of OWNER’s premises for repair, Owner shall have the right to withhold the payment for such cost of equipment to the extent of payment made by Owner towards the equipment until the equipment is returned / replaced.

1.2.8.8 Packing

1.2.8.8.1 CONTRACTOR shall ensure that packing of EQUIPMENT is as required to prevent their damage or deterioration during transit to its final destination.

1.2.8.8.2 The packing, markings and documentation within and outside the packages shall comply strictly with the provisions of CONTRACT.

1.2.8.8.3 CONTRACTOR shall be responsible for any eventual consequence occurred to EQUIPMENT due to improper packing of the same.

1.2.8.9 Delivery/Time Schedule and Documents
1.2.8.9.1 Time schedule shall include time for submission of documents/drawings for review/approval, incorporation of comments, if any, and final review of drawings by ENGINEER-IN-CHARGE. Within 14 (Fourteen) working days after receipt by ENGINEER-IN-CHARGE of any document requiring OWNER’s review, ENGINEER-IN-CHARGE shall either return one copy thereof to CONTRACTOR as it is, if ENGINEER-IN-CHARGE has no comments or with its comments and reasons thereof.

1.2.8.9.2 Special care shall be taken by CONTRACTOR to furnish Manufacturer’s Test Certificates, material of construction, make, type, pressure ratings wherever applicable and included in the scope of supply of EQUIPMENT.

1.2.8.9.3 In case of delayed delivery beyond the stipulated COMPLETION PERIOD, for reasons not attributable to OWNER, FORCE MAJEURE and suspension of WORK by OWNER, even though provisional extension of COMPLETION PERIOD time is allowed by OWNER, all extra costs on account of changes of statutory regulations/Acts or increase in price on any other account including price variation clause, shall not apply to CONTRACT PRICE and the same shall be borne by CONTRACTOR.

1.2.8.10 Despatch, Transportation/Shipping

1.2.8.10.1 CONTRACTOR shall be responsible for despatch of EQUIPMENT by sea/ rail/ road/air after proper packing and protection. The consignment shall be despatched after inspection by OWNER unless otherwise agreed to in writing however such inspection shall not constitute waiver of the CONTRACTOR’s obligations, responsibilities for the EQUIPMENT including care, safety and preservation in any way and manner and the CONTRACTOR’s responsibility and obligation in this behalf shall continue till PRELIMINARY ACCEPTANCE OF PLANT.

1.2.8.10.2 Generally, on-Deck shipment shall not be made without prior permission of OWNER. However, in case of towers, reactors, vessels and other large-sized EQUIPMENT, CONTRACTOR may, at its own discretion, make on-deck shipment, without OWNER’s prior permission. In case of damage to such EQUIPMENT, during delivery or at any stage before PRELIMINARY ACCEPTANCE OF PLANT, CONTRACTOR shall be responsible for repair/replacement of EQUIPMENT.

1.2.8.10.3 Clean onboard bill of lading for all offshore supplies shall be drawn as under:

For CIF/FOB/FAS/FCA shipments

<table>
<thead>
<tr>
<th>Shipper</th>
<th>= CONTRACTOR/Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consignee</td>
<td>= CONTRACTOR</td>
</tr>
</tbody>
</table>
1.2.8.10.4 Property in EQUIPMENT

1.2.8.10.4.1 In case of all EQUIPMENTS/MATERIALS (both imported and indigenous), the title of Ownership shall pass on to OWNER on PRELIMINARY ACCEPTANCE of Plant. However, the OWNER shall have Lien on all EQUIPMENTS/MATERIALS including those brought by the Contractor for the purpose of Erection, testing and commissioning of the WORK. However, in case of Termination of Contract the Transfer of Title shall pass automatically to OWNER.

1.2.8.10.4.8 CONSTRUCTION EQUIPMENT used by the CONTRACTOR and its SUB-CONTRACTORS in connection with the execution of works shall remain the property of CONTRACTOR or its SUB-CONTRACTORS. All duties, levies, taxes etc payable on account of CONSTRUCTION EQUIPMENT shall be borne by the CONTRACTOR. CONTRACTOR shall indemnify the OWNER on this count.

1.2.8.10.5 Assembly Marks and Name Plates

1.2.8.10.5.1 All component/parts of EQUIPMENT shall be indelibly hard marked with identification marks, comprising EQUIPMENT, part numbers, and CONTRACT number/PO number which shall also be shown on drawing to facilitate speedy identification, assembling or dismantling.

1.2.8.10.5.2 On each EQUIPMENT, a nameplate indicating basic details, pressure rating, wherever applicable, code number of EQUIPMENT, electrical characteristics in case of electrical EQUIPMENT, name of instrument with tag no., manufacturer’s name shall be fixed at proper place.

1.2.8.10.5.3 For packages where marking is not possible at least two metallic nameplates must be affixed. Marking on the plates will be by means of engraving or indelible paint and will include the information listed above.

1.2.8.10.6 Despatch/Shipping notice

1.2.8.10.6.1 CONTRACTOR shall notify OWNER by fax/E-mail for its information the expected date of delivery of a consignment, date of readiness of EQUIPMENT for shipment, total gross weight and total volume with dimensions.

1.2.8.10.7 Heavy Lift Consignment (HLC) or Over Dimensional Consignments (ODC).

1.2.8.10.7.1 CONTRACTOR shall follow the guidelines of Ministry of Road transport and Highways (MORTH) India, for the shipping/transportation of all packages/consignments. The CONTRACTOR shall be responsible to comply with rules relating to E-way Bills and other related provisions under the GST laws for movement of packages/consignments.
1.2.8.10.7.2 CONTRACTOR shall make his own arrangements for movement of all consignments including ODC.

1.2.8.10.7.3 CONTRACTOR confirms that it has surveyed the route for transportation of ODC items of EQUIPMENT and CONTRACTOR further confirms that it has included all cost of repairs of road, civil works, strengthening of bridges, culverts, widening of roads, etc. as required for transportation of ODC items of EQUIPMENT in its CONTRACT PRICE. OWNER shall not be responsible for repairs of road, civil works, strengthening of bridges, culverts, widening of roads, etc. as required for the transportation of ODC items of EQUIPMENT and shall not be liable to reimburse the cost of such repairs of road, civil works, strengthening of bridges, culverts, widening of roads, etc. to CONTRACTOR.

1.2.8.10.8 Marking

1.2.8.10.8.1 CONTRACTOR shall mark the following on packing three sides i.e. two sides faced and cover (Top) EQUIPMENT with indelible paint in conspicuous printed letters not less than 5 cm. in size in English:

A. For Imported EQUIPMENT

   Government of India  
   A/c TALCHER PROJECT, ODISHA, INDIA.

   a) CONTRACT /PO NO. : _____________________
   b) Equipment Description and Item Nos. : _____________________
   c) Package : _____ of _________
   d) Gross / Net Weight (Kgs.) : _____________________
   e) Dimension L x W x H cms. : _____________________
   f) WARNING MARKS (FRAGILE, ATTENTION, TOP, KEEP DRY ETC.)
   g) Forwarding No. : _____________________
   h) Part shipment/full shipment/final shipment : _________________
   i) Each package shall bear a symbol contained in the package as follows:

   ‘A’ Storage in a closed storehouse.
   ‘B’ Storage under a shed.
   ‘C’ Storage in the open.
1.2.8.10.8.2 Depending on the characteristics of the contents in the packages, the packages have to be marked with appropriate international marking ("HANDLE WITH CARE"; "THIS SIDE UP"; "SLING MARK"; ETC.) and other indications necessary for correct handling such as Centre of Gravity and points of slinging (in case of heavy loads).

1.2.8.10.8.3 For packages where marking is not possible, at least two metallic nameplates must be affixed. Marking on the plates will be by means of engraving or indelible paint and will include the information listed above.

1.2.8.10.8.4 All corners of the packages shall be painted with indelible ‘Blue’ paint at least 125 mm in depth for easy identification/location of the packages for clearance and handling at the port.

1.2.8.10.9 Packing List

1.2.8.10.9.1 CONTRACTOR will include in each package an item-wise packing List, Invoice No. and associated drawings.

1.2.8.10.9.2 The packing list and any other documents shall be put in a closed polyethylene envelope and included in each package.

1.2.8.10.9.3 A second copy of the packing list shall be placed in a polyethylene envelope on the outside of each package by means of metallic plate marked “Documents”. As regards columns, exchangers and similar equipment, the envelope shall be placed in a nozzle being identified by an arrow, in indelible paint, followed by the word “Document”.

1.2.8.10.9.4 Shipping documents must always be presented in the number of copies indicated in this CONTRACT.

1.2.8.10.11 Shipping Arrangements and Forwarding of Documents

CONTRACTOR shall avoid the use of over aged vessels for the shipment of the imported EQUIPMENT under this CONTRACT and if so used, the cost of additional insurance, if any, shall be borne by CONTRACTOR.

1.2.8.10.12 Despatch/Shipment Notice for Insurance.

1.2.8.10.12.1 CONTRACTOR shall send intimations of despatches indicating items despatched, quantity, value, weight and carrier particulars directly through fax to the insurance company fixed by CONTRACTOR. A copy of this letter/ intimation shall also be given to commercial negotiating bank for payment against Letter of Credit. Copies shall also be sent to OWNER.

1.2.8.10.12.2 Insurance for transit risks and other risks shall be covered by CONTRACTOR.

1.2.9 Spares, Special Maintenance Tools, Lubricants, Chemicals and Consumable
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2.9.1</td>
<td>CONTRACTOR shall procure and supply commissioning spares, special maintenance tools and fixtures for EQUIPMENT, lubricants, chemicals and consumable in sufficient quantity for COMMISSIONING and maintenance of PLANT, as described in FINAL PROPOSAL. The commissioning spares, special maintenance tools, lubricants, chemicals and consumable procured and supply shall be optimum, so as not to fall short during COMMISSIONING, Sustained Load Test and GTR. CONTRACTOR shall obtain for these items the appropriate guarantees and warranties. CONTRACTOR shall also ensure that the commissioning spares and special maintenance tools and fixtures are procured along with the related items of EQUIPMENT and form part of PURCHASE ORDER for the related items of EQUIPMENT.</td>
</tr>
</tbody>
</table>
| 1.2.9.2 | **Lubricants, Chemicals, Consumable etc.**  
CONTRACTOR shall supply Consumables, lubricants and chemicals required for 100% full load run for 6 months operation after successful commissioning (and include the cost in CONTRACT PRICE). Consumables, lubricants and chemicals to be supplied in phased manner shall be mutually agreed between OWNER and CONTRACTOR considering the consumption and storage capacity. |
| 1.2.9.3 | **Special Maintenance Tools**  
CONTRACTOR shall supply special devices or tools required for normal maintenance, special handling and lifting of EQUIPMENT with main EQUIPMENT. The cost of such special maintenance tools shall be included in CONTRACT PRICE. |
| 1.2.9.4 | **Bidder’s Recommended Operational Spares**  
CONTRACTOR shall provide Itemised Price List for Bidder's Recommended operational spares 6 months prior to Mechanical Completion with validity of 2 Years. The recommended spares shall be optimum so as not to cause any short fall or excessive inventory. The price of above shall NOT be included in CONTRACT PRICE. |
| 1.2.9.5 | **Special Tools & Tackles**  
CONTRACTOR shall supply special tools, tackles and fixture, required during normal operation & maintenance of PLANT. The cost of such special tools & tackles shall be included in CONTRACT PRICE. |
| 1.2.9.6 | **Chemicals**  
CONTRACTOR shall supply all chemicals for first filling and make-up required as indicated in Technical Section of NIT. The cost of these chemicals shall be included in the CONTRACT PRICE. |
| 1.2.9.7 | **Lubricants** |
1.2.9.7.1 CONTRACTOR shall supply lubricants in sufficient quantity for the first filling and make-up required as indicated in Technical Section of NIT. The cost of lubricants shall be included in the CONTRACT PRICE.

1.2.9.7.2 CONTRACTOR shall furnish the name of recommended lubricants indicating their commercial/trade name, quality and grade and equivalent quality lubricants (in case of imported lubricants) available in India to OWNER.

1.2.9.8 Commissioning spares and Consumables

CONTRACTOR shall supply spares and consumables required for construction, PRE COMMISSIONING, COMMISSIONING, start-up and testing of PLANT. The cost of such spares and consumables shall be included in TOTAL CONTRACT PRICE.

1.2.9.9 Mandatory Spares

CONTRACTOR shall provide Mandatory Spares as per Section VI-10.0, of Technical Document. Notwithstanding anything contained in this CONTRACT, the Prices for Mandatory Spares/Insurance Spares shall be included in TOTAL CONTRACT PRICE.

The Lumpsum price for “Mandatory Spares/Insurance Spares” shall be as included in the supply portion of Total Contract Price. However, details along with breakup for the above shall be submitted by successful bidder during execution.

1.2.9.10 General

1.2.9.10.1 CONTRACTOR shall furnish to OWNER, the blue prints, drawings and specifications of the spare parts.

1.2.9.10.2 CONTRACTOR shall provide to OWNER all addresses and particulars of its SUB-CONTRACTOR/VENDOR on whom PURCHASE ORDER for EQUIPMENT covered under CONTRACT has been placed and will further ensure with its SUB-CONTRACTOR/VENDOR that, OWNER if so desires, shall have the right to place order for two years spare parts directly on them on mutually agreed terms based on offers of such SUB-CONTRACTOR/ VENDOR.

1.2.9.10.3 Spare parts shall be new and as per engineering standards/codes, free of any defects (even concealed), deficiency in Design, Materials and Workmanship and also shall be completely interchangeable with the corresponding parts.

1.2.9.10.4 Type and sizes of bearing/seals and bearing number with make shall be clearly indicated.

1.2.9.10.5 Spare parts shall be packed for long storage under tropical climatic conditions in suitable cases, clearly marked as to their intended purpose.

1.2.10 Warrantees and Guarantees
1.2.10.1  Materials and Workmanship Warranty

1.2.10.1.1 CONTRACTOR warrants that EQUIPMENT supplied under CONTRACT are new, unused, of the recent or current models and incorporate all recent improvements in design and materials unless provided otherwise in CONTRACT. CONTRACTOR further warrants that EQUIPMENT supplied under this CONTRACT shall be according to specifications, have no defect (even concealed) arising from design, materials or workmanship or form any act or omission of CONTRACT that may develop under normal use of the supplied EQUIPMENT in the conditions prevailing in the country of final destination.

1.2.10.1.2 The warranty period for the EQUIPMENT supplied by CONTRACTOR shall be valid for minimum 12 months for all EQUIPMENT except for catalysts from the date of PRELIMINARY ACCEPTANCE. The warranty period for individual catalyst shall be up to its guaranteed life, as specified in FINAL PROPOSAL, from the date of PRELIMINARY ACCEPTANCE.

1.2.10.1.3 The warranty shall be valid for the period as described under Clause -1.2.10.1.2 from the date of PRELIMINARY ACCEPTANCE and shall be governed by Clause 17 of SPECIAL CONDITIONS OF CONTRACT. Should any DEFECTS be noticed in design, material and/or workmanship within the said warranty period, ENGINEER-IN-CHARGE shall inform CONTRACTOR and CONTRACTOR shall immediately on receipt of such intimation depute their personnel within 10 DAYS to investigate the causes of DEFECTS and arrange rectification / replacement / modification of the defective EQUIPMENT at SITE without any cost to OWNER, within a reasonable period. If CONTRACTOR fails to take proper corrective action to replace/ repair defective Equipment satisfactorily within a reasonable period, OWNER shall be free to take such corrective action as may be deemed necessary at CONTRACTOR’s risk and cost, after giving notice to CONTRACTOR. OWNER shall promptly notify CONTRACTOR in writing of any claims arising under this warranty.

1.2.10.1.4 In case defects are of such nature that EQUIPMENT shall have to be taken to CONTRACTOR’s/ SUB-CONTRACTOR’s/ vendor’s works for rectification etc., CONTRACTOR shall take EQUIPMENT at its cost after giving necessary undertaking or security as may be required by OWNER. OWNER shall, if so required by CONTRACTOR, despatch EQUIPMENT by quickest mode on freight to pay basis to CONTRACTOR’s / SUB-CONTRACTOR’s / vendor’s works. After repairs CONTRACTOR shall deliver EQUIPMENT at SITE on freight paid basis. All transit risks to and from site shall be borne by CONTRACTOR.

1.2.10.1.5 EQUIPMENT or part thereof so repaired or replaced shall have further warranty for a period of 12 months from the date of its acceptance after repair/replacement and the Performance Bank Guarantee shall be suitably extended for the same. The value of the Performance Bank Guarantee during the extended warranty period shall be 10 (Ten) percent of the cost of such repaired/replaced EQUIPMENT or its parts for which documentary evidence to be submitted.
However, extended DEFECTS LIABILITY PERIOD shall have an upper limit of 24 months for extended DEFECTS LIABILITY PERIOD, starting from the Preliminary Acceptance.

1.2.10.1.6 If the repairs, replacements or modifications referred to above are of such nature which may affect the efficiency of EQUIPMENT, OWNER shall have right to give notice in writing to CONTRACTOR within one month of such repair/ replacement/ modification to carry out tests as may be required for acceptance of EQUIPMENT.

1.2.10.1.7 If CONTRACTOR fails to meet its obligation to repair or replace defective EQUIPMENT and make it good within a reasonable period of time and or if CONTRACTOR refuses to carry out WORK under the guarantee clause and implied guarantee conditions and/or in case of severe urgency, OWNER shall be entitled to carry out repair/replacement/WORK or arrange to carry out repair/ replacement/WORK by a third party. The entire cost of such repair/ replacement/WORK including transit insurance, freight, taxes and duties etc. shall be borne by the CONTRACTOR. In case, the cost of such repair/replacement has been incurred by OWNER, CONTRACTOR shall reimburse the same immediately on demand by OWNER with a document substantiating such costs.

1.2.10.1.8 Damages to EQUIPMENT deriving from incomplete, erroneous instructions issued by CONTRACTOR will be considered CONTRACTOR’s fault and will be treated according to the provision of warranty clause. Normal wear and tear shall not come under purview of this clause.

1.2.11 Performance Guarantee of PLANT / EQUIPMENT

1.2.11.1 CONTRACTOR guarantees that the performance of PLANT supplied under CONTRACT shall be strictly in conformity with the specifications and shall perform the duties and have consumption, production and other guarantees set forth in CONTRACT.

1.2.11.2 If the performance of PLANT and/or any of EQUIPMENT fails as guaranteed and set forth in CONTRACT, CONTRACTOR shall investigate the causes and provide free of cost to OWNER, design, engineering, MATERIALS and services and EQUIPMENT within a reasonable period to prove guarantees. CONTRACTOR’s liability in this respect shall be limited as per the provisions of 32.0 of GCC except that the Works Cost Guarantee shall be governed by the provisions of Cl.No.31.2. of GCC.

1.2.12 Government Clearances, Permits and Certificates

1.2.12.1 CONTRACTOR shall procure at its expenses, all necessary APPLICABLE PERMITS, certificates and licenses required by virtue of all APPLICABLE LAWS, regulations, ordinances and other rules in effect at the place where any of WORK is to be performed, and CONTRACTOR shall further hold OWNER harmless from liability or
penalty which might be imposed by reason of any asserted or established violation of such laws, regulations, ordinances or other rules. OWNER will provide the necessary assistance to CONTRACTOR for obtaining PERMITS for CONTRACTOR’s personnel to undertake WORK in India in connection with CONTRACT.

1.2.12.2 CONTRACTOR shall furnish necessary technical information, data, drawing, etc. as and when required by OWNER for submission to Government/Statutory Agencies.

1.2.13 Network Schedule

1.2.13.1 OWNER would be using a computerized time and cost monitoring system and CONTRACTOR shall provide necessary input data for the same. CONTRACTOR shall prepare within 30 (thirty) days from date of FOA and provide to OWNER a PROJECT MASTER SCHEDULE indicating the important milestones of activities relating to WORK from date of FOA to the date of PRELIMINARY ACCEPTANCE. This PROJECT MASTER SCHEDULE shall be discussed with and approved by OWNER. Based on the approved PROJECT MASTER SCHEDULE, CONTRACTOR shall also prepare network schedules for activities relating to WORK. CONTRACTOR shall obtain the details of progress of various activities of WORK from SUB-CONTRACTOR and vendor wherever required and update the network schedules and PROJECT MASTER SCHEDULE incorporating the progress achieved by CONTRACTOR, SUB-CONTRACTOR and vendor and submit the same to ENGINEER-IN-CHARGE on monthly basis.

1.2.13.2 CONTRACTOR shall clearly indicate any delay in WORK in the above schedules and shall inform ENGINEER-IN-CHARGE the action taken to achieve the COMPLETION PERIOD.

1.2.13.3 Time Schedule Network/Bar Chart

1.2.13.3.1 Within 30 (thirty) DAYS from the date of FOA, CONTRACTOR shall submit to ENGINEER-IN-CHARGE its time schedule regarding delivery of documentation, supply and manufacture of EQUIPMENT, time schedule for placement of purchase order and SUB-CONTRACT, etc.

1.2.13.3.2 The time schedule will be in the form of a network and a bar chart clearly indicating all main or key events regarding documentation, supply of raw materials, manufacturing, testing and delivery of equipment, civil works, erection, commissioning, testing etc.

1.2.13.3.3 The original issue and subsequent revisions of such time schedule shall be sent to OWNER in two copies (of which one shall be a reproducible/soft copy). The time schedule network/bar chart shall be updated at least every month during the period of CONTRACT.

1.2.13.4 Progress of WORK
1.2.13.4.1 CONTRACTOR shall report monthly to OWNER of the execution of CONTRACT and achievement of targets set out in time bar chart, in a monthly progress report on 7th working day of every Month.

1.2.13.4.2 The progress shall be expressed in percentages for all activities.

1.2.13.4.3 The first issue of the progress report shall be forwarded together with the time bar chart.

1.2.13.4.4 OWNER shall also review the physical/actual progress of WORK on the basis of CONTRACTOR's time schedule documentation.

1.2.13.4.5 Irrespective of such review, CONTRACTOR shall advise OWNER at the earliest possible date of any anticipated delay in the progress.

1.2.13.4.6 In the event that the delay is caused by a delay in the delivery of a sub-contracted EQUIPMENT, CONTRACTOR shall be responsible for such delay and submit details together with copies of the appropriate orders and agreements with SUB-CONTRACTOR/vendor.

1.2.14 **Transportation and Storing of EQUIPMENT**

1.2.14.1 CONTRACTOR shall be responsible for proper packing, transportation from vendor's workshop to port or railway station (whether by road, rail, ship or aircraft), handling and clearances at port or railway station including loading and unloading, customs clearance, carriage to SITE, unloading at SITE, warehousing, coding and tagging, storage including proper preservation, etc. of EQUIPMENT. Any special clearance, lifting, handling, loading/unloading, and transport arrangements for over dimensional consignments shall also be done by CONTRACTOR. CONTRACTOR shall ensure timely delivery of EQUIPMENT. CONTRACTOR shall endeavor to have the consignments in the upper part of the hold to enable early discharge at the Port of disembarkment. The above arrangement shall be in accordance with the guidelines set forth in the Co-ordination Procedure. CONTRACTOR shall be responsible for inspection of EQUIPMENT on receipt at SITE and for maintenance and management of stores and warehousing of EQUIPMENT at SITE including all activities connected with the issue of EQUIPMENT, accounting and final reconciliation and handing over of stores to OWNER.

1.2.14.2 OWNER shall provide area at SITE for making shed/covered stores etc. for storing EQUIPMENT. CONTRACTOR shall be responsible for making shed/covered stores etc. for safe storage of EQUIPMENT.

1.2.15 **Construction**

1.2.15.1 CONTRACTOR shall be responsible for all civil and structural work, foundations, insulating & painting works, erection, site fabrication, piping, instrumentation, electrical installation, and other miscellaneous construction jobs of PLANT leading to
MECHANICAL COMPLETION and PRELIMINARY ACCEPTANCE of PLANT. CONTRACTOR shall organise these activities in appropriate sequence and use proper methods giving due regard to the requirements of safety, quality, sound engineering practice, compliance with relevant Codes and Regulations, and for achieving PRELIMINARY ACCEPTANCE of PLANT on or before COMPLETION PERIOD.

The CONTRACTOR shall within the scope of work observe in addition to specifications, all national and local laws, ordinances, rules and regulation and requirements pertaining to the WORK.

Various procedures and methods to be adopted by CONTRACTOR during the construction as required in the respective specifications shall be submitted to OWNER in due time and well in advance of the specific work for approval.

The CONTRACTOR shall carry out required supervision as per Quality Assurance Plan and furnish all assistance required by the OWNER in carrying out inspection work. The OWNER will have authorised representatives present who shall have free access to the work at all times. If an OWNER's representative notifies the CONTRACTOR's representative of any deficiency in any work or in the supervision thereof, the CONTRACTOR shall make every effort to carry out such instructions consistent with best industry practice.

The CONTRACTOR shall so far as reasonably feasible employ skilled workers who are Certified Tradesmen in the field(s) of their relative activities(s).

1.2.15.2 CONTRACTOR shall submit and adhere to the completion schedule of construction leading to PRELIMINARY ACCEPTANCE.

1.2.15.3 In case of delay in completion beyond the stipulated completion period as specified in Invitation For Bid (IFB) under clause 2 (E) for reasons attributable to Contractor, all extra costs on account of changes of statutory regulations / Acts, shall not apply to Contract price and the same shall be borne by Contractor.

1.2.15.4 Civil Work Warranty

1.2.15.4.1 CONTRACTOR shall certify that the all civil works, reinforced concrete, structures, permanent buildings and foundations has been designed in accordance with stipulations of relevant BIS Codes.

1.2.16 Safety and Plant Security

1.2.16.1 CONTRACTOR shall observe and also use its best efforts to ensure that all parts of WORK carried out at SITE is being done in a safe and satisfactory manner conforming
to the applicable Safety Rules and Regulations. Further, CONTRACTOR shall observe and make provisions in SUB-CONTRACT that employees working for PLANT observe all the Safety Rules as required under the Factories Act and Regulations and other Local Laws and SUB-CONTRACTOR to provide safety apparel and equipment to its employees. OWNER shall have the right to object to any unsafe practice followed by SUB-CONTRACTOR’s employees or any CONTRACTOR’s personnel and direct them to carry out the job in a manner considered safe by OWNER. CONTRACTOR shall further abide by all the Security Regulations imposed by OWNER.

1.2.16.2 CONTRACTOR shall observe all safety rules so that no harm is done to OWNER’s employees or property. If on account of CONTRACTOR, OWNER’s property or personnel are likely to suffer any damage, in such cases any directions issued by OWNER shall be carried out by CONTRACTOR.

1.2.17 PRE-COMMISSIONING Services of PLANT

1.2.17.1 CONTRACTOR shall render and be responsible for pre-commissioning activities leading to MECHANICAL COMPLETION. These activities will include relevant checking, adjustment, testing, calibration, running in and trial runs of individual items of EQUIPMENT, and other similar jobs. OWNER shall provide experienced/trained and suitable operating and maintenance personnel who will perform their tasks under the supervision and direction of CONTRACTOR.

1.2.17.2 CONTRACTOR shall provide experienced personnel as required for carrying out the PRE-COMMISSIONING activities with OWNER’s personnel.

1.2.17.3 CONTRACTOR shall provide SUB-CONTRACTOR’s/VENDOR’s specialists wherever required. Suitable provision for such services shall be made by CONTRACTOR in PURCHASE ORDER/CONTRACT with their Sub-Vendor/Sub-Contractor.

1.2.18 MECHANICAL COMPLETION

1.2.18.1 CONTRACTOR shall be responsible for completing the design, engineering, procurement, inspection and expediting, arranging for transportation of EQUIPMENT, construction and PRE-COMMISSIONING for making PLANT ready for acceptance of feed stock on declaration of MECHANICAL COMPLETION.

1.2.19 Commissioning Services of PLANT

1.2.19.1 CONTRACTOR shall be responsible for COMMISSIONING after PRE-COMMISSIONING activities have been completed giving due regard to safety of EQUIPMENT according to sound international practice. OWNER shall provide operating and maintenance personnel who shall work under the supervision and direction of CONTRACTOR. The COMMISSIONING activities shall include but not limited to the following:
a) Introduction of raw materials, utilities, lining-up of various sections of PLANT leading to production of Steam as per Section VI-4.0 of NIT

b) Stabilising PLANT and stepping up production to full plant capacity.

c) Demonstrating and Conducting sustained load test and Guarantee Test as per Section VI-8.0 of NIT

1.2.19.2 CONTRACTOR shall provide engineers as required to commission the PLANT. CONTRACTOR shall be responsible to provide supervision personnel for operation of PLANT for a period of 6 months from date of successful commissioning and OWNER will operate the PLANT under the supervision and instructions of CONTRACTOR.

During the sustained load test and the guarantee test, the range of operating conditions shall be within the limits of the design conditions and shall meet the requirements of safety and compliance with relevant Codes and Regulations.

1.2.20 Performance Guarantee Test Run

1.2.20.1 CONTRACTOR shall successfully complete PERFORMANCE TEST as early as possible after MECHANICAL COMPLETION as specified in Technical Section-VI, 8.0 of NIT.

1.2.20.2 CONTRACTOR shall, when PLANT is stabilized at full plant capacity to the satisfaction of OWNER, shall carry out PERFORMANCE TEST and prove Guarantees.

1.2.21 Deleted.

1.2.22 6 months Supervisory Assistance.

Owner requires six months supervisory assistance after successful Commissioning with designated selected manpower defined by Owner as per the requirement specified in Technical Section VI-3.0, of NIT. LSTK Contractor shall include the cost of above services in TOTAL CONTRACT PRICE.

1.2.23 Laws and Regulations

1.2.23.1 CONTRACTOR shall abide, while fulfilling its obligations, by all applicable codes and APPLICABLE LAWS from time to time in force in the State of ODISHA and in India. FINAL PROPOSAL shall be based on the codes, and regulations applicable on the date of submission of the FINAL PROPOSAL.

In the event of change in any codes, legislation, laws or regulation applicable to PLANT WORK or any part thereof after date of submission of FINAL PROPOSAL, which alters the scope of CONTRACTOR’s obligations under CONTRACT,
CONTRACTOR shall agree to make the necessary changes in scope of WORK. Such changes shall be governed by CHANGE IN WORK as per the provisions of Clause -3 of SCC. Any additional fee becoming applicable due to any change of Acts, regulations, by-laws, orders and requirements after date of submission of FINAL PROPOSAL shall be borne by OWNER in accordance with SCC clause 3.0.

1.2.24 Statutory Obligations

1.2.24.1 CONTRACTOR shall comply with the requirements of statutory provisions and shall be solely responsible for fulfilment of all legal obligations under Contract Labour (Regulation and Abolition) Act, Inter-state Migrant Workmen (Registration of Employment and Condition of Service) Act, Payment of Wages Act, Workmen Compensation Act, Factories Act, Employees Provident Fund and Misc. Provisions Act, Payment of Bonus Act, Payment of Gratuity Act, Industrial Disputes Act and all other applicable Industrial/Labour enactment and Rules made there under as applicable from time to time. In case OWNER incurs any liability towards payment of any kind whatsoever, due to non-fulfilment of statutory provisions under any industrial/labour law by CONTRACTOR, the same shall be made good by CONTRACTOR.

1.2.24.2 SUB-CONTRACTOR engaged by CONTRACTOR for performing civil and erection work/other jobs at SITE shall have PF Code No. in its name issued by Regional Provident Fund Commissioner (RPFC).

1.2.24.3 The CONTRACTOR shall ensure that the SUB-CONTRACTOR shall comply with the Statutory Requirements, as applicable, for the execution of this CONTRACT.

1.2.25 Progress Monitoring and Reporting

1.2.25.1 CONTRACTOR shall develop a suitable system for monitoring and reporting progress on the various activities up to PRELIMINARY ACCEPTANCE. CONTRACTOR shall submit PROJECT MASTER SCHEDULE and detailed Network Schedule covering the activities and milestones starting from date of FOA until PRELIMINARY ACCEPTANCE, as described under Clause -1.2.13 above. These schedules shall include the activities of CONTRACTOR, SUB-CONTRACTOR/Sub-Vendor. CONTRACTOR shall monitor progress continuously and submit to EIC monthly progress reports giving the status of the activities, indicating those delayed and action being taken, or required to be taken, to bring back those activities on schedule. These reports will also include progress at vendor’s workshops and shall be supplemented with photographs, wherever necessary. The Network Schedule shall be updated once in a month. CONTRACTOR shall also furnish information to ENGINEER-IN-CHARGE as may be required by any other Government Authority or any other agency such as Financing Institution etc.

1.2.26 Technical Information
1.2.26.1 CONTRACTOR shall furnish to OWNER, CONTRACTOR’s Technical Information and know-how as may be necessary for the operation of PLANT and relating to its process according to the provisions of Article 53 of General Conditions of Contract. CONTRACTOR shall grant or cause to be granted to OWNER an irrevocable right to use all such above technical information for PLANT and shall further advise OWNER for a period of five (5) years from date of PRELIMINARY ACCEPTANCE of any improvements in process, know-how, engineering, operation methods, and other conditions which will result in more efficient operation of PLANT that are developed by CONTRACTOR or process licensor or have come to the knowledge of CONTRACTOR, at no extra cost to OWNER. OWNER shall also grant to CONTRACTOR, at no extra cost to CONTRACTOR, to the benefit of process licensor the same right on OWNER’s improvements as per the provisions of this Clause. Notwithstanding the generality of the foregoing, ownership of data, technical information processes, technology or software proprietary to CONTRACTOR and/or SUBCONTRACTORS shall remain with CONTRACTOR and/or SUBCONTRACTOR. CONTRACTOR and/or SUBCONTRACTOR shall ensure that OWNER is legally entitled to use of such data, processes, technology and software in the form of a perpetual, non-terminable, non-exclusive, royalty-free License for the purpose of the operation and maintenance of the PLANT.

1.2.27 Work of SUB-CONTRACTOR and vendor

1.2.27.1 CONTRACTOR shall remain responsible for proper execution of such part of WORK as are carried out by its SUB-CONTRACTOR and vendor and any failure of SUB-CONTRACTOR/vendor shall not relieve CONTRACTOR of its obligations under CONTRACT. Furthermore, in the event of any default by SUB-CONTRACTOR/vendor, CONTRACTOR shall either take over SUB-CONTRACTOR/vendor’s part of WORK on mutually agreed terms or take remedial action as may be necessary in order to comply with COMPLETION PERIOD and any other activities leading to PRELIMINARY ACCEPTANCE.

1.2.28 Co-ordination

1.2.28.1 CONTRACTOR shall render all necessary assistance to ENGINEER-IN-CHARGE required for overall co-ordination of all activities connected with WORKS. For this purpose, CONTRACTOR and ENGINEER-IN-CHARGE shall agree on a meeting as soon as practicable after issuance of FOA, with SUBCONTRACTOR/vendor’s and such other parties as are necessary to settle the following:

- a) Review the basic design conditions set forth in FINAL PROPOSAL and where appropriate, review possibilities of standardisation.
- b) Assess the priorities and key dates required to be included in CONTRACTOR’s PROJECT MASTER SCHEDULE.
- c) Make an assessment of all items requiring co-ordination.
- d) Fix up a date and agenda of any subsequent meeting as may be required in association with OWNER.
e) Discuss with ENGINEER-IN-CHARGE and furnish all technical information about various effluents/emission and discharge points from different sources indicating the quality and quantity of gaseous and liquid emission of pollutants from PLANT. CONTRACTOR shall also supply ENGINEER-IN-CHARGE any additional information required on the above matter during the performance of process design and basic engineering design.

In the event, ENGINEER-IN-CHARGE pursuant to its responsibilities of overall co-ordination requests CONTRACTOR to make any alteration to the programme, scope of responsibility under CONTRACT, CONTRACTOR shall do the same, subject to the provisions of Clause 3.0.

1.2.29 Notices and Reports

1.2.29.1 CONTRACTOR shall submit the following copies of notices to ENGINEER-IN-CHARGE as part of the Scope of Work:

a) Immediate notification of safety incidents and accidents, including near misses, of any kind or type followed as soon as possible after such event by a full report.

b) Notices from any Government / Statutory Agency or any other Person for a violation of any Law or Government Approval, immediately upon receipt by CONTRACTOR and no later than twenty-four (24) hours after its receipt.

c) Inspection reports by any inspector whether relating to any accident, accepting any test reports or otherwise immediately upon receipt by CONTRACTOR and no later than two (2) working DAYS after its receipt.

d) Any other matter/issue that involves OWNER's interest.

1.2.30 CONTRACTOR's Representative and Key Personnel

1.2.30.1 CONTRACTOR shall with prior consent of ENGINEER-IN-CHARGE, appoint a CONTRACT MANAGER to manage the execution of WORK and to be nominated as CONTRACTOR's Representative. CONTRACTOR’s personnel stationed at SITE for providing services during the execution of WORK shall work under the supervision and guidance of CONTRACT MANAGER. The CONTRACT MANAGER shall have the full authority to make binding and enforceable decisions in the name of CONTRACTOR and shall receive all notices/correspondence that OWNER serves on CONTRACTOR.

1.2.30.2 CONTRACTOR shall be responsible for the work performed by CONTRACT MANAGER and CONTRACTOR’s personnel and shall under no circumstances be relieved of its responsibilities and obligations under CONTRACT on account of acts or omissions of CONTRACT MANAGER and personnel.
1.2.30.3 The Key Personnel shall hold the staff positions as indicated in CONTRACT. CONTRACTOR shall use reasonable efforts to ensure that such Key Personnel will be engaged in the execution of WORK continuously until their role is completed unless prior release is approved by OWNER, such approval not to be unreasonably withheld or delayed. Replacement of or addition to Key Personnel shall only be made with persons having qualifications and experience equal to or better than those replaced or added to, and shall be similarly subject to OWNER’s prior approval. In the event, any person identified in CONTRACT decides to leave the employment of CONTRACTOR, CONTRACTOR shall use reasonable efforts to retain the services of such person until his portion of WORK is complete. CONTRACTOR further agrees not to remove from WORK Key Personnel, which OWNER considers to be necessary for the proper performance of WORK without the prior written approval of OWNER.

1.2.31 General Warranties

a) CONTRACTOR shall perform WORK in full compliance with its FINAL PROPOSAL and all other terms and conditions set forth herein.

b) WORK shall be performed, in a good and workmanlike manner and in accordance with the FINAL PROPOSAL, all other terms and conditions of this CONTRACT, all DOCUMENTS, all Government Approvals, all APPLICABLE LAWS, and Good Industry Practices.

c) All EQUIPMENT, installed as part of PLANT, (i) shall be free from any encumbrance or lien and shall conform to the specifications and descriptions set forth in CONTRACT and (ii) shall be new and unused, free from DEFECTS and Deficiencies of any kind and shall meet the requirements of the Scope of Work.

d) The completed PLANT shall be free of DEFECTS and Deficiencies and shall be designed, constructed and engineered, in compliance with the Scope of Work.

e) PLANT shall be designed, engineered, constructed, tested, completed and delivered based on Good Industry Practices, CONTRACTOR’s specifications and guidelines for operation and maintenance in accordance with the Scope of Work, for CONTRACT PRICE and no later than the COMPLETION PERIOD.

f) All SUB-CONTRACTOR/vendor shall perform their portion of the Scope of Work or supply or install EQUIPMENT in accordance with the applicable terms set forth herein.

g) Adherence to the Operations Manual shall allow safe start-up, operation, maintenance and shut-downs of the completed PLANT, in accordance with CONTRACTOR’s guidelines and will not impair any warranty or guarantee of EQUIPMENT incorporated or to be incorporated into PLANT.
1.2.32.1 CONTRACTOR shall incorporate during design stage maximum utilization of goods manufactured and/or available in India and also avail shipping, insurance, banking, catering and any other services available from India-owned companies for installation of plant, if quality, delivery and overall cost characteristics are equivalent.

1.2.32.2 CONTRACTOR shall arrange insurance pursuant to Clause 28.0 of GCC, at its own cost.

1.2.32.3 CONTRACTOR shall provide necessary information, documentation, and assistance for obtaining any approvals from Financial Institutions or any other agencies or authorities.

2.0 OWNER'S OBLIGATIONS

OWNER shall be responsible for fulfilling all obligations as specified under the following heads:

2.1 Deleted

2.2 Overall Co-Ordination

The objective of overall co-ordination is to organise orderly execution of WORK, bring about requisite integration amongst the various project activities of executing agencies, to avoid interference between the various activities of the parties in order to achieve the earliest possible completion of WORK. The aim will be to integrate, have compatibility between plants and uniform standardisation of design, engineering, layout, etc.

2.3.0 Review and Approval of Work

2.3.1 CONTRACTOR shall associate OWNER’s representatives with WORK as carried out by CONTRACTOR’s personnel. For this purpose, OWNER shall associate with WORK at all stages. Specifically, OWNER shall undertake the following tasks:

   a) Review/APPROVAL of drawings as per Technical Section and other documents connected with basic and detailed engineering.

   b) Review of specifications for EQUIPMENT, lists of spare parts and special maintenance tools, and lists of special construction aids, tools, tackles, and fixtures.

   c) Participation in inspection, expediting and testing of EQUIPMENT at SUB-CONTRACTOR’s / vendor’s works and at SITE, wherever considered necessary by OWNER.
2.3.2 For the smooth functioning, OWNER will nominate an individual who will act as EIC under the CONTRACT. The EIC will have full authority to act on behalf of the OWNER in connection with the CONTRACT. Except as otherwise provided in the CONTRACT, all communications between the OWNER and the CONTRACTOR relating to the WORKS shall be between the ENGINEER-IN-CHARGE and the CONTRACT MANAGER.

2.4 Deleted

2.5 Facilities for CONTRACTOR's Personnel

OWNER shall assist CONTRACTOR in obtaining Visas and other PERMITS from the appropriate authorities for CONTRACTOR's and SUB-CONTRACTOR's / vendor's expatriates to enter and stay in India as necessary for performance of WORK. OWNER shall also provide facilities to CONTRACTOR's expatriates in accordance with the provisions described in Clause-2.8.

2.6 Operating and Maintenance Personnel

OWNER shall provide operating and maintenance personnel according to its organisation, specifications, and standards during the PRE-COMMISSIONING and COMMISSIONING activities, who will work under the direction and control of CONTRACTOR. OWNER may associate its personnel with the construction and erection of PLANT to familiarise the personnel with WORK, and generally to prepare for proper operation and maintenance of PLANT.

2.7 Feed stock and Utilities

OWNER shall make available the feedstock and utilities as specified in section VI-2.0 of bid document for commissioning and PGTR.

2.8 Site Facilities

OWNER shall provide the following SITE facilities:

a) Land for Construction Activities
b) General safety and security without prejudice to Contractor’s obligations.
c) Construction Power & Construction Water shall be provided as per clause 1.1.1 (g)
d) Free and unrestricted access to SITE for CONTRACTOR’s Authorized Personnel

Owner shall NOT provide any accommodation and facilities for travelling to and from SITE to the place of residence to the personnel of CONTRACTOR, deputed at SITE for performing WORK under CONTRACT.
g) OWNER shall NOT provide any accommodation and facilities for travelling to and from SITE to the place of residence to the personnel of SUB-CONTRACTOR and VENDOR.

h) Area for making shed/covered storage for storing EQUIPMENT.

3.0 CHANGES IN WORK/CHANGE ORDER

3.1 OWNER may at any time order change in work scope. OWNER shall have the right to request in writing changes in WORK within the scope of CONTRACT. When the request for a change in WORK by OWNER has been agreed and complied by CONTRACTOR, CONTRACTOR’s obligations under CONTRACT shall remain unaffected unless otherwise agreed.

Changes may consist of additions, deletions or revisions of the Scope of Work, and may cause the CONTRACT PRICE, the work schedule or the COMPLETION PERIOD or any other CONTRACTOR’s WARRANTIES to be adjusted.

CONTRACTOR shall be entitled to an extension of time to COMPLETION PERIOD suffered and/or payment of additional costs incurred as a result of any change in law or legislation, by way of a CHANGE ORDER, in case it is necessitated or if it becomes applicable.

3.2 The ENGINEER IN CHARGE shall have the right to make any alterations in, omission from, additions to or substitutions for in the scope of work, the original specifications, drawings, designs and instructions that may appear to him to be necessary or advisable during the progress of the WORK and the CONTRACTOR shall be bound to carry out the such altered/ extra/ new items of WORK in accordance with any instructions which may be given to him in writing signed by the ENGINEER IN CHARGE, and such alterations, omissions, additions or substitutions shall not invalidate the CONTRACT and any altered, additional or substituted work which the CONTRACTOR may be directed to do in the manner above specified as part of the WORK shall be carried out by the CONTRACTOR on the same conditions in all respects on which he agreed to do the main WORK. The time of completion of WORK may be extended for the part of the particular job at the discretion of the ENGINEER IN CHARGE, for only such alterations, additions or substitutions of the WORK, as he may consider as just and reasonable. The rates for such additional, altered or substituted WORK under this clause shall be worked out in accordance with the following-

CONTRACTOR shall, within 7 days of the date of receipt of order to carry out the WORK, inform the ENGINEER IN CHARGE of the rates which it is his intention to charge for such class of WORK, supported by analysis of the rate or rates claimed, and the ENGINEER IN CHARGE shall determine the rate or rates on the basis of the prevailing market rates, labour cost at schedule of labour rates plus 10% to cover contractor's supervision, overheads and profit and pay the CONTRACTOR accordingly. The opinion of the ENGINEER IN CHARGE as to current market rates of
materials and the quantum of labour involved per unit of measurement will be final and binding on the CONTRACTOR.

3.3. If it is established that a request for Change in Work asked by Owner does not fall under original Scope of Contract, then CONTRACTOR shall promptly submit cost estimate, and / or time extension and / or terms of payment (as applicable) for making the requested change in WORK together with the details of any variation required to be made to any of CONTRACTOR’s or OWNER’s obligations and/or guarantees as per clause 3.2 above.

3.4 If in CONTRACTOR's opinion fulfillment of any of its obligations under CONTRACT would be jeopardised by a CHANGE IN WORK requested by OWNER, then CONTRACTOR shall explain in writing to OWNER the reasons for not accepting these changes within thirty (30) days of receipt of OWNER's written request.

3.5 OWNER and CONTRACTOR shall agree upon the basis and terms of the CHANGE IN WORK in writing.

3.6 It is understood that no change shall become effective and no change will alter the scope of WORK until all of the matters referred to in this Clause 3 have been mutually agreed upon in writing by OWNER and CONTRACTOR.

3.7 It is agreed by both parties that the following changes shall not be considered a CHANGE IN WORK in the meaning in this Clause:

   a) Minor changes requested by OWNER and accepted by CONTRACTOR which do not involve any substantial additional cost or man-hour effort, and have no effect on contractual completion period, and/or

   b) Any change necessitated due to requirements of prevalent laws in India upto the time of submission of FINAL PROPOSAL.

3.8 This clause is to be read in conjunction with Clause No. 5.0 of GCC.

4.0 ACCEPTANCE OF PLANTS AND FACILITIES

CONTRACTOR's liabilities for the Performance Guarantees given for the PLANTS and Facilities in respect of capacity, consumption, product quality and pollution level shall be discharged only when the PERFORMANCE AND GUARANTEE TESTS as stipulated in Technical, Section VI-8 of NIT have been successfully carried out as per Plant Acceptance criteria specified at Clause 5.0 below and OWNER has issued PRELIMINARY ACCEPTANCE CERTIFICATE.

5.0 PLANT ACCEPTANCE CRITERIA
Subject to fulfilling PERFORMANCE AND GUARANTEE TESTS as per Section VI-8.0 of NIT and Clause 18.0 of SCC, OWNER shall be in readiness to accept the PLANT. CONTRACTOR shall take all steps to fulfil the provisions of the CONTRACT for OWNER to issue PRELIMINARY ACCEPTANCE CERTIFICATE. The care and custody responsibility of the Plant shall be passed on to OWNER on PRELIMINARY ACCEPTANCE of the Plant.

6.0 ISSUANCE OF PRELIMINARY ACCEPTANCE CERTIFICATE

Within 30 (thirty) DAYS from completing successfully PERFORMANCE & GUARANTEE TESTS by the CONTRACTOR and CONTRACTOR fulfilling all the obligations under the provision of the CONTRACT, OWNER shall issue PRELIMINARY ACCEPTANCE CERTIFICATE to CONTRACTOR. On issue of this Certificate by OWNER, CONTRACTOR shall become entitled to receive all associated payment as per provisions of the CONTRACT due to CONTRACTOR subject to CONTRACTOR’s fulfilling the obligations stipulated under CONTRACT.

7.0 LABOUR AND STAFF

7.1 The CONTRACTOR shall make his own arrangement for labour, erection and COMMISSIONING engineers and all other staff required for carrying out the WORK. The necessary permissions from Government of India regarding work permit and visa requirement shall be obtained by the CONTRACTOR.

7.2 The CONTRACTOR shall make his own arrangements for providing canteen service to his labour and staff. Open space for this purpose may be provided by OWNER.

7.3 The CONTRACTOR shall at his own cost provide office and other accommodation for his staff and workmen. The CONTRACTOR shall also provide communication, transport and medical facilities to his staff and workmen.

7.4 The CONTRACTOR shall be responsible for all statutory obligations and any other laws in this regard in force from time to time regarding the employment or conditions of service of CONTRACTOR’s labour, workman or employees.

7.5 The CONTRACTOR shall observe all safety rules as required under various rules, regulations and laws in India and shall also strictly adhere to safety regulations of OWNER.

8.0 TRAINING OF OWNER'S PERSONNEL
8.1 The CONTRACTOR shall provide facilities for Training of OWNER's personnel in the operation and maintenance of plant at CONTRACTOR's other similar installations. The timing of training shall be mutually discussed and agreed between the parties. The costs towards travel, transportation and living expenses of the OWNER's personnel shall be borne by OWNER.

CONTRACTOR shall make arrangements, for training of OWNER’s personnel in similar PLANT of CONTRACTOR's design having comparable capacity and design features and in VENDOR's workshops (Refer Section VI-12.0 of Technical part of NIT). CONTRACTOR shall provide assistance to OWNER's personnel for proper co-ordination and management of the practical experience. Detailed programme and modalities for practical experience shall be mutually agreed between OWNER and CONTRACTOR.

9.0 MODE OF CONTRACTING

9.1 Notwithstanding anything stated elsewhere in the CONTRACT documents, the CONTRACT is awarded on Lumpsum turnkey basis with single point responsibility.

9.2 The CONTRACT shall be in all respect being construed and governed in accordance with the Indian laws.

9.3 The Contract shall be treated as a “WORK CONTRACT SERVICE”.

10.0 BID PRICES

10.1 The Bid price is to be filled in the formats given in Schedule of Rates (SOR).

10.2 The TOTAL CONTRACT PRICE quoted shall be firm and fixed without any escalation whatsoever on any account except the statutory variations in Taxes levied by the Government of India within GUARANTEED COMPLETION DATE and otherwise specified in the CONTRACT.

11.0 CURRENCIES OF BID AND PAYMENT

11.1 BIDDER to quote prices in Indian Rupees (INR) only.

ROUNDING-OFF OF AMOUNTS:

In calculating the amount of each item due to the CONTRACTOR in every invoice prepared for payment, sum of less than 50 paise shall be omitted and the total amount on each invoice shall be rounded off to the nearest rupees, i.e., sum of less than 50 paise shall be omitted and sums of 50 paise and more upto one rupee shall be reckoned as one rupee.
11.2 The Lumpsum price quoted by the CONTRACTOR shall be gross of Indian Income Tax, and the lumpsum price(s) shall be deemed to include Indian Income Tax including withholding tax (if any).

12.0 PRICES, TAXES AND DUTIES AND OTHER LEVIES

12.1 Except as specifically provided to the contrary in the SPECIAL CONDITIONS OF CONTRACT:

(i) The CONTRACTOR shall, within the price of materials and scope of supply, be liable to pay and bear any and all duties, taxes, levies and cesses lawfully payable on any goods, equipment or materials imported into India or within any local limits for permanent incorporation in the work(s), and on materials sold and supplied to the OWNER pursuant to the CONTRACT.

(ii) The CONTRACTOR shall within the price of services and scope of services be responsible to pay on behalf of the OWNER any and all duties, taxes, levies and cesses including education cess etc. lawfully payable on any goods or equipment imported into India or within any local limits for use in the performance of the work(s), and on services performed pursuant to the CONTRACT.

(iii) The CONTRACTOR shall be liable for and shall pay any and all Indian fees, taxes, duties, levies and cesses including education cess etc., assessable against CONTRACTOR in respect of or pursuant to the CONTRACT. However, GST payment by the CONTRACTOR to the Tax Authority shall be made by the Owner to the CONTRACTOR at actual limited to the Amount indicated in the Bid.

(iv) In addition, the CONTRACTOR shall be responsible for payment of all Indian duties, levies, and taxes etc., assessable against the CONTRACTOR or CONTRACTOR's employees or SUB-CONTRACTOR'S whether corporate or personal or applicable in respect of property.

12.2 Deleted.

12.3 TAX INDEMNITY

It will be the duty of the CONTRACTOR to duly observe and perform all laws, rules, regulations, orders and formalities applicable under GST and Customs Duty on the manufacture, sale, import and/or supply of any material to OWNER and/or applicable on the services performed by the CONTRACTOR pursuant hereto. The CONTRACTOR shall keep the OWNER indemnified for and against any and all claims, demands, prosecutions, penalties, damages, demurrages and/or other levies.
whatever made or levied by the Court or Customs Authorities with respect to any alleged breach, evasion or infraction of such duties, taxes, charges or levies or any breach or infraction of such laws, rules, regulations, orders or formalities concerning the same and from the consequence thereof.

12.4 All the applicable taxes, duties etc. on supply of materials, services and otherwise required for execution of contract on LSTK Basis as quoted in Schedule of Rates (SOR) shall be included in the TOTAL CONTRACT PRICE.

12.5 The CONTRACTOR confirms that, it has included all taxes, duties, levies etc., as applicable at prevailing rates, in its TOTAL CONTRACT PRICE as quoted in Schedule of Rate. In case, CONTRACTOR has not included any such taxes, duties, levies etc., at all and/or at prevailing rates and CONTRACTOR has to pay such taxes, duties, levies etc., OWNER shall not be liable for payment of such liabilities and/or OWNER shall not reimburse such taxes, duties, levies etc. to CONTRACTOR.

12.6 The award of work shall be on ‘Work Contract Service’ basis. The contractor shall be responsible for payment of any tax levied on the transfer of property and goods involved with relevant GST act and rules made there under including amendments, if any. The contractor shall be liable to have registered with the respective tax authorities and to submit self-attested copy of such registration certificate(s) and any taxes/ duties/ levies being charged by the Contractor would be claimed by issuing proper tax invoice/challan indicating details/ elements of all taxes charged and necessary requirements as prescribed under the respective tax laws and also to mention correct and valid registration number(s) on all tax invoices raised to TFL.

12.7 Any other taxes / duties in relation to this CONTRACT, which in terms of relevant legislation is the liability of CONTRACTOR, is discharged by OWNER, would be recovered from the CONTRACTOR from any subsequent payment due to the CONTRACTOR.

12.8 INCOME TAX

12.8.1 CONTRACT PRICE shall be inclusive of any and all Indian Income Tax payable in India. OWNER shall deduct Indian Income Tax as per rates prescribed for such contracts from time to time, from the payments due to CONTRACTOR and issue Tax Deducted at Source (TDS) certificate to CONTRACTOR. It will the responsibility of the CONTRACTOR to file proper income tax return and pay taxes thereon if any, or claim refund thereof if any. The CONTRACTOR shall give OWNER all necessary documents relating to its income tax assessments and to keep the OWNER informed about their assessments.

12.8.2 Personal income tax payable, if any, in respect of salary and perquisites of CONTRACTOR's personnel / SUB-CONTRACTOR's personnel in India shall be payable by the individual so deputed by CONTRACTOR or SUB-CONTRACTOR. It is the responsibility of the individual or CONTRACTOR to file proper income tax return and pay taxes thereon if any, or claim refund thereof if any. The CONTRACTOR shall
give OWNER all necessary documents relating to income tax assessments of its personnel and to keep the OWNER informed about their assessments.

12.9 Applicable BOCW shall be included in the quoted TOTAL CONTRACT PRICE. The CONTRACTOR shall pay the labour cess under BOCW Act, 1996 for CONTRACT as applicable. The CONTRACTOR shall submit the proof of submission of labour cess to OWNER before submitting the next RA bill. However applicable BOCW shall be deducted at source from the CONTRACTOR’s bill as per latest tax rule.

13.0 STATUTORY VARIATION IN TAXES AND DUTIES

13.1 No variation on account of taxes and duties, statutory or otherwise, (other than due to change in turnover) shall be payable by OWNER to CONTRACTOR, except for GST. Any statutory variation in GST, shall be payable up to COMPLETION PERIOD against documentary evidence. Any reduction in the amount of GST resulting from a reduction in the rate of GST or remission or exemption from GST with respect to Goods and Services provided to the OWNER shall be refundable to the OWNER at actuals within the COMPLETION PERIOD and also during the delayed contractual Project completion, if any. The CONTRACTOR shall submit a copy of the 'Government Notification' to evidence the rate as applicable on the Bid due date and on the date of revision.

13.2 Any new taxes, duties, cess, levies notified or imposed after the submission of Price Bid but before COMPLETION PERIOD shall be to OWNER’s Account.

13.3 In case of delayed completion beyond the COMPLETION PERIOD, even though extension of completion time is allowed by OWNER, for reasons solely attributable to Contractor, all extra costs on account of changes of statutory regulations/ acts, or shall not apply to the Contract price and shall be borne by the CONTRACTOR.

However, any decrease in taxes and duties during the delayed period shall be passed on to the OWNER.

In case the COMPLETION PERIOD is extended for reasons solely attributable to OWNER, then any increase on account of statutory changes in GST until the extended period shall be borne by OWNER. Further, any new taxes, duties, cess, levies notified or imposed after the submission of Price Bid during such extended COMPLETION PERIOD shall be to OWNER’s Account.

13.4 Claim for payment of GST (CGST & SGST/UTGST or IGST)/ Statutory variation, should be raised within two [02] months from the date of issue of ‘Government Notification’ for payment of differential (in %) GST (CGST & SGST/UTGST or IGST), otherwise claim in respect of above shall not be entertained for payment of
arrears.

The base date for the purpose of applying statutory variation shall be the Bid Due Date.

14.0 TERMS OF PAYMENT

14.1 Deleted

14.2 MOBILISATION ADVANCE

The CONTRACTOR shall be paid an interest bearing recoverable Mobilisation Advance limited to maximum 10% (Ten percent) of the TOTAL CONTRACT PRICE (excluding GST) provided Bank Guarantee is submitted by the CONTRACTOR for 110% of advance (including GST).

The interest rate shall be at Marginal cost of fund based landing rate (MCLR) for one year charged by SBI (applicable on the date of disbursement of Mobilisation Advance) plus 2.0% per annum on reducing balance basis.

The interest bearing Mobilization Advance shall be paid in two installments. The first installment of advance shall be maximum 50% of the Mobilisation Advance. Further the disbursement of second installment of balance amount can be made at the end of 3 months from the first installment subject to utilization certificate of first installment but not earlier than 3 months from the date of disbursal of first installment.

Mobilization Advance shall be paid subject to fulfillment of the following conditions:

a) Unconditional Acceptance of Fax of Acceptance (FOA) by CONTRACTOR.

b) Submission of Bank Guarantee(s) for 110% value of the said advance(s) including GST, valid for 3 months beyond COMPLETION PERIOD, as per format F-4. The CONTRACTOR shall, at the request of the OWNER, suitably extend the validity of the Bank Guarantee (s) for such period or periods as may be required to fully recover the amount of the Advance Payment not recovered before the expiry of the validity of such Bank Guarantee, failing which, without prejudice to any other right or remedy available to the OWNER, the OWNER shall be entitled to encash the Bank Guarantee (s)."

c) Submission of Bank Guarantee(s) by way of Contract Performance Security as stipulated in Clause 8.0 of the GENERAL CONDITIONS OF CONTRACT. The CONTRACTOR shall at the request of the OWNER extend the validity of the Bank Guarantee(s) for such further period or periods as may be required failing which, without prejudice to any other right or remedy available to the OWNER, the OWNER shall be entitled to encash the Bank Guarantee(s).

Notes:
1. The CONTRACT PRICE for the purpose of Security cum Performance Bank Guarantee would be derived on date of CONTRACT and would not be revised except in case scope of work is altered.

2. The advance paid to the CONTRACTOR shall be used only for execution of this CONTRACT and the CONTRACTOR shall satisfy the OWNER in this regard whenever required. If it is found that the said advance has been utilised by the CONTRACTOR in whole or part for any other purpose, the OWNER may at its discretion forthwith recall the entire advance and without prejudice to any other right or remedy available to the OWNER, recover the same by recourse to any Bank Guarantee(s).

3. Mobilization Advance shall be recovered from the Running Account Bills @ 15% (Fifteen Percent) of the Certified Bill amount and shall be fully extinguished within 12 months from the date of disbursement of first installment of advance. In case, the recovery of advance is delayed beyond 12 months from the date of disbursement of first installment of advance for any reason, interest shall be levied @ 1 year SBI MCLR + 2% for the unadjusted amount for the delayed period beyond 12 months from the date of disbursement of first installment of advance.

4. Bank Guarantee furnished by the Contractor towards mobilization advance may be reduced quarterly subject to adjustment made from Contractors running bill. The BG against Mobilization advance shall be returned immediately after full recovery of advance.

5. The advance(s), without prejudice to any other mode of recovery available to the OWNER, be recovered from the Running Account Bills @ 15% (Fifteen percent) of the Certified Bill amount and any balance amount shall be fully extinguished within 12 months from the date of disbursement of first installment of advance.

6. The payment curve ie S curve/Monthly Payment Schedule should be prepared after considering the mobilization advance and it’s recovery.

7. In case of termination of CONTRACT due to default by CONTRACTOR, advance Bank Guarantee shall be enchased and unadjusted advance payment recovery will become interest bearing (the interest rate shall be simple interest of 1 year MCLR + 5.25%) calculated from the date of disbursement of first installment of advance.

14.3 Subject to the other provisions of the Contract documents, payments shall be made as follows:

14.3.1 Mobilisation Advance:
Interest bearing Mobilization advance limited to 10% of Contract value shall be given, if asked by the Bidder, as indicated above.

Bidder to indicate their requirement as to the quantum of first installment of Mobilization Advance( not more than 6% of the contract price) and the second installment of Mobilization Advance such that first installment and the second installment add up to 10% of the CONTRACT PRICE.

14.3.2 A FOR SUPPLIES:

i) 10% (Ten Percent) of Total supply value excluding GST (excluding, spares, construction material, consumables) will be released on placement of all purchase orders as per the list of major tagged items to be finalised within 45 days from date of issuance of FOA. This payment shall be released after submission of Bank Guarantee for equivalent value. This Bank Guarantee shall be valid up to 3 months after the COMPLETION PERIOD and may be renewed, as per the instruction of OWNER for such extended period. However, this Bank Guarantee shall be released after receipt of all SUPPLIES (excluding, spares, construction material, consumables) at SITE and acceptance of same.

ii) AGAINST PROOF OF SHIPMENT / DESPATCH OF MATERIALS:

35% (Thirty five percent) on pro-rata basis as indicated in the approved Billing schedule (refer clause 15.0 below). Stage payment against "Proof of despatch of Materials" shall be released on submission of the following documents:

a) Signed Invoice(s)
b) Delivery Challan
c) Packing list.
d) Manufacturer's certificate of inspection for shipment duly approved by the CONTRACTOR in one original and one photocopy
e) Third Party Inspection Release Note clearly indicating that material has been inspected and accepted as per QAP approved by OWNER, or waiver certificate issued by OWNER.
f) Railway Receipt/LR
g) Insurance Certificate/Intimation
h) Guarantee certificate (wherever applicable)
i) Operation & Maintenance manual (wherever applicable)

iii) AGAINST RECEIPT OF MATERIAL AT SITE:

40% (Forty percent) on pro-rata basis as indicated in the approved Billing schedule on submission of:

(a) Signed Invoices.
(b) Photocopy of Third Party Inspection certificate as per QAP approved by OWNER along with Test Certificate.
(c) Entry gate pass duly endorsed by OWNER’s security for verification of physical entry of material to SITE.

(d) Certificate of Verification and Good Condition after receipt of material at site by Owner.

iv) 5% (five percent) as indicated in the approved Billing schedule on issue of MECHANICAL COMPLETION Certificate against CONTRACTOR’s certified running Accounts Bill(s).

v) 8% (Eight percent) as indicated in the approved Billing schedule on issue of PRELIMINARY ACCEPTANCE CERTIFICATE against the CONTRACTOR’s certified Running Account Bills.

vi) 2% (Two percent) as indicated in the approved Billing schedule on completion of balance jobs, if any, against the CONTRACTOR’s Certified Final Bill.

B FOR SPARES, CHEMICALS, CATALYST, LUBRICANTS:

i. AGAINST PROOF OF SHIPMENT / DESPATCH OF MATERIALS:

45% (Forty five percent) on pro-rata basis as indicated in the approved Billing schedule. Stage payment against "Proof of despatch of Materials" shall be released on submission of the following documents with the CONTRACTOR's invoice.

a) Signed Invoice(s)
b) Delivery Challan
c) Packing list.
d) Manufacturer’s certificate of inspection for shipment duly approved by the CONTRACTOR in one original and one photocopy
e) Third Party Inspection Release Note clearly indicating that material has been inspected and accepted as per QAP approved by OWNER, or waiver certificate issued by OWNER.
f) Railway Receipt/LR
g) Insurance Certificate/Intimation
h) Materials Safety Data Sheet (MSDS) for Chemicals & Catalyst

ii) AGAINST RECEIPT OF MATERIAL AT SITE:

40% (Forty percent) on pro-rata basis as indicated in the approved Billing schedule on submission of:

(a) Signed Invoices.
(b) Photocopy of Third Party Inspection certificate as per QAP approved by OWNER along with Test Certificate.
(c) Entry gate pass duly endorsed by OWNER’s security for verification of physical entry of material to SITE.

(d) Certificate of Verification and Good Condition after receipt of material at site by Owner.

iii) 5% (five percent) as indicated in the approved Billing schedule on issue of MECHANICAL COMPLETION Certificate against CONTRACTOR’s certified running Accounts Bill(s).

iv) 8% (Eight percent) as indicated in the approved Billing schedule on issue of PRELIMINARY ACCEPTANCE CERTIFICATE against the CONTRACTOR’s certified Running Account Bills.

v) 2% (Two percent) as indicated in the approved Billing schedule on completion of balance jobs, if any, against the CONTRACTOR’s Certified Final Bill.

14.3.3 FOR SERVICES (EXCLUDING TRAINING OF OWNER’S PERSONNEL AND INLAND TRANSPORTATION)

i) 5% (five percent) on issue of MECHANICAL COMPLETION Certificate against CONTRACTOR’s certified running Accounts Bill(s).

ii) 8% (Eight percent) on issue of PRELIMINARY ACCEPTANCE CERTIFICATE against the CONTRACTOR’s certified Running Account Bills.

iii) 2% (Two percent) on completion of balance jobs, if any, against the CONTRACTOR’s Certified Final Bill.

iv) 85% (Eighty Five) progressive Payment as indicated in the approved Billing schedule subject to the other provisions of the Contract documents, as per the monthly progress achieved.

14.3.4 FOR CIVIL AND STRUCTURAL WORKS

i) 5% (five percent) on issue of MECHANICAL COMPLETION Certificate against CONTRACTOR’s certified running Accounts Bill(s).

ii) 8% (Eight percent) on issue of PRELIMINARY ACCEPTANCE CERTIFICATE against the CONTRACTOR’s certified Running Account Bills.

iii) 2% (Two percent) on completion of balance jobs, if any, against the CONTRACTOR’s Certified Final Bill.

iv) 85% (Eighty Five) Payment as indicated in the approved Billing schedule subject to the other provisions of the Contract documents, Bidder will have the option to fix the other milestone payment according to Contract requirement.
14.3.5 **TRAINING OF OWNERS PERSONNEL**

100% (Hundred Percent) of payment shall be released on completion of training as indicated in the approved Billing schedule.

14.3.6 **INLAND TRANSPORTATION**

100% (Hundred Percent) of Local Transportation charges (including inland transit insurance charges) for the plant and equipment including mandatory spares/insurance spares and also recommended spares (if ordered) shall be paid to the Contractor as indicated in the approved Billing schedule on pro-rata to the value of the equipment/spares received at site and on production of invoices by the Contractor.

14.3.7 **6 MONTHS SUPERVISORY ASSISTANCE**

100% (Hundred percent) on monthly basis as indicated in the approved Billing schedule.

14. 4 All payments other than the Mobilization Advance shall be released only after finalization of the planning and monitoring documents and Progress Schedule.

14. 5 All invoices shall be submitted in quadruplicate to EIC by the Bidder. The payment shall be released within 30 days of submission of invoice.

15.0 **BILLING SCHEDULE**

The CONTRACTOR shall provide a billing schedule based on Monthly payment Schedule (S-curve) within 30 days from the date of FOA for APPROVAL by the OWNER.

The Billing Schedule shall consist of the following Heads:

<table>
<thead>
<tr>
<th>1.0 SUPPLIES (Break-up in line with the Material Control Index-MCI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Total of Supplies (excluding Spares, Chemicals, Lubricants)</td>
</tr>
<tr>
<td>b. Mandatory/Insurance Spares as per list enclosed in Section VI-10</td>
</tr>
<tr>
<td>c. Chemicals</td>
</tr>
<tr>
<td>d. Lubricants</td>
</tr>
<tr>
<td>e. Others</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.0 SERVICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Basic Engineering (Break-up In line with the Document Control Index-DCI)</td>
</tr>
<tr>
<td>b. Detailed Engineering (Break-up In line with the Document Control Index-DCI)</td>
</tr>
<tr>
<td>c. Installation</td>
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**3.0 Civil And Structural Works**

**4.0 Transportation Charges**

**5.0 Training of Owner’s Personnel**

**6.0 6 months supervisory assistance after successful commissioning**

The CONTRACTOR shall raise “Tax Invoices” on the OWNER against the GST to enable OWNER to reimburse the same.

Similarly, in case of imports, the import duty paid shall have to be indicated separately in the invoice, duly supported by all the necessary documents, so as to enable the OWNER to reimburse the same.

Likewise, the GST paid on the local procurements by the CONTRACTOR have to be shown separately with all the supporting documents to enable the owner to reimburse the same.

The Bill of Entry shall have to be filed by the CONTRACTOR within the stipulated time with the appropriate authorities.

**Note**

1. Bidder shall indicate all Prices in INR only

2. Spares for Start-up/ Commissioning and Mandatory Spares/ Insurance Spares are in CONTRACTOR’s scope of supplies and are to be included in the quoted TOTAL CONTRACT PRICE.

3. It will be the responsibility of the contractor to include prices of all materials/ equipments/Services/Civil & Structural Works required for completion of work as per the CONTRACT.

4. The total price payable under the CONTRACT shall be restricted to TOTAL CONTRACT PRICE.

5. The Civil & Structural Works shall include but not limited to the Price of Piling, Equipment Foundation, Buildings, Structural Works, etc.
6. Total price of SUPPLIES shall not exceed 60% of the TOTAL CONTRACT PRICE. The SUPPLIES shall include but not limited to the Price of all imported /indigenous materials complete in all respect including Commissioning and Mandatory Spares, etc.

7. Total price of Basic Engineering and Detailed Engineering quoted in shall not exceed 10% of the TOTAL CONTRACT PRICE. The supply of Services shall include but not limited to the Price of all services complete in all respect including Basic Engineering, Detailed Engineering, installation/Erection Services including site fabrication, Transportation, Insurance, Pre-Commissioning, Commissioning, Performance Guarantee Test Run (PGTR), etc.

8. CONTRACTOR shall be entirely responsible for all taxes, cess, stamp duties, and other such levies applicable, on performance of WORK under CONTRACT, outside OWNER’s country. CONTRACTOR shall also be responsible for payment of all taxes, duties and levies such as custom duty, GST, income tax, etc. as applicable on performance of WORK under CONTRACT, in India. All such taxes, stamp duties, cess, licence fees, and other such levies applicable shall be included in the quoted TOTAL CONTRACT PRICE.

16.0 DEEMED ACCEPTANCE

In case conductance of PERFORMANCE GUARANTEE TEST RUN (PGTR) of the PLANT is delayed by 12 months from successful COMMISSIONING due to reasons solely attributable to the OWNER, PLANT shall be considered as DEEMED ACCEPTED with a DEFECT LIABILITY PERIOD of another 12 months from DEEMED ACCEPTANCE. The CONTRACT PERFORMANCE SECURITY shall be extended, accordingly, by the CONTRACTOR.

In case of DEEMED ACCEPTANCE, a reasonable cost for conductance of Performance Guarantee Tests shall be worked out mutually and shall be retained by OWNER. Payment against PRELIMINARY ACCEPTANCE less the aforesaid retention amount shall be released upon DEEMED ACCEPTANCE of the PLANT. The bank guarantee already running as CONTRACT PERFORMANCE SECURITY shall be extended, by the CONTRACTOR so as to ensure validity of three (03) months beyond the date of completion of DEFECT LIABILITY PERIOD.

This provision of DEEMED ACCEPTANCE shall not be applicable in case reasons for delay solely attributable to the OWNER are resolved before the completion of 12 months from successful COMMISSIONING and PERFORMANCE GUARANTEE TEST RUN is started within 12 months from successful COMMISSIONING. In that case, remaining activities including PERFORMANCE GUARANTEE TEST RUN shall be completed as per the terms & conditions of the CONTRACT and CONTRACT PERFORMANCE SECURITY shall be extended, accordingly, by the CONTRACTOR so as to ensure minimum validity of 3 months beyond the expiry of f DEFECT LIABILITY PERIOD.

Even after the DEEMED ACCEPTANCE, CONTRACTOR shall not be absolved from his obligations of carrying out PGTR. However, in such case, the CONTRACTOR shall have no obligation to prove the Performance Guarantee parameters.
The CONTRACTOR may, in consultation with the OWNER, demobilise the team from the Site. It shall remobilise at the time of conductance of PGTR by OWNER which shall be within DEFECT LIABILITY PERIOD. The OWNER shall, in addition to the cost retained as above, reimburse the reasonable cost to be incurred by the CONTRACTOR for remobilization.

In case of DEEMED ACCEPTANCE, OWNER shall be responsible for care, custody and proper maintenance of the PLANT. However, OWNER, at its option, may retain the CONTRACTOR’s services for watch, ward and preservation of the PLANT and reimburse the CONTRACTOR a mutually agreed reasonable cost incurred to do so.

After Deemed Acceptance, on performance of PGTR by the CONTRACTOR, if the Guaranteed parameters are not achieved, then the CONTRACTOR shall furnish the Recommendation/Report for corrective action to be implemented by OWNER to achieve the desired Guaranteed parameters.

17.0 LIABILITY FOR DEFECT

17.1 If at any time before the PRELIMINARY ACCEPTANCE or during the DEFECT LIABILITY PERIOD stated below, the OWNER:

(a) Claims that any matter is a DEFECT; and

(b) as soon as reasonably practicable gives to the CONTRACTOR notice of the particulars of the DEFECT; the CONTRACTOR shall as soon as reasonably predictable make good the DEFECT so notified and the OWNER shall so far as may be necessary place the PLANT at the CONTRACTOR’s disposal for this purpose. The CONTRACTOR shall, if so required by the EIC, submit his proposals for making good any DEFECT to the EIC for his approval.

Subject to clauses 17.4, 17.8 and 17.9, the DEFECT LIABILITY PERIOD shall be a period of 12 months from the date of PRELIMINARY ACCEPTANCE/DEEMED ACCEPTANCE.

17.2 If any DEFECT arises from any breach of the CONTRACT by the CONTRACTOR, the CONTRACTOR shall bear his own cost of making good the DEFECT. In the case of any other matter made good by the CONTRACTOR, the work done by the CONTRACTOR shall be the subject of CHANGE ORDER.

17.3 The performance guarantees are demonstrated only through the performance tests carried out before the achievement of the PRELIMINARY ACCEPTANCE CERTIFICATE.

CONTRACTOR shall carry out further test(s) on the repaired/replaced item during the DEFECT LIABILITY PERIOD having the sole purpose to verify that said item is capable of working in compliance with contractual requirements. Such test(s) shall not be intended as a repetition of the performance tests already performed.

If DEFECT is made good after the issue of a PRELIMINARY ACCEPTANCE CERTIFICATE, the EIC may require the CONTRACTOR to repeat any appropriate performance test for the purpose of establishing that the DEFECT has been made good.
The CONTRACTOR shall be responsible for the cost of any repeat inspection or test in the event of an inspection or test failure.

17.4 If in the course of making good any DEFECT which arises during the DEFECT LIABILITIES PERIOD and CONTRACTOR repairs, replaces or renew any part of the PLANT, this Clause 17 shall apply to the repair or to that part of the PLANT so replaced or renewed and shall further apply until the expiry of a period of 12 months from the date of such repair, replacement or renewal (the extended DEFECT LIABILITY PERIOD). However, extended DEFECT LIABILITY PERIOD shall have an upper limit of 24 months, starting from the date of Preliminary Acceptance Certificate.

17.5 If the CONTRACTOR does not make good with a reasonable time any DEFECT which he is liable to make good under Sub-Clause 17.1 then the OWNER may, in addition to any other remedies or relief available to him under the CONTRACT, proceed to do the work, provided that the OWNER gives at least fourteen DAYS notice of his intention.

17.6 If the OWNER reasonably requires that any DEFECT notified to the CONTRACTOR under Sub-clause 17.1 which arises during the DEFECT LIABILITY PERIOD be made good urgently and the CONTRACTOR is unable or refuses to comply within a reasonable time, the OWNER may, in addition to any other remedies or relief available to him under the CONTRACT, proceed to do the work in such a manner as the ENGINEER-IN-CHARGE may decide, including the employment of a third party.

17.7 If the OWNER has made good a DEFECT in accordance with Sub-clause 17.5 or 17.6, the CONTRACTOR shall reimburse the OWNER his reasonable cost of so doing provided that the OWNER gives a notice to the CONTRACTOR of his intention and submits a claim supported by DOCUMENTS. The ENGINEER-IN-CHARGE and the CONTRACTOR may agree the amount to be paid by the CONTRACTOR, or in the absence of agreement the ENGINEER-IN-CHARGE shall decide such amount as may be reasonable. Such amount shall be:

a) deducted from any money that would otherwise be payable under the CONTRACT; or

b) paid by the CONTRACTOR to the OWNER

17.8 If the PLANT cannot be used because of a DEFECT to which this Clause 17 applies, the DEFECT LIABILITY PERIOD, or if applicable the extended DEFECT LIABILITY PERIOD, shall be extended by a period equal to the period during which it cannot be used. Similarly the DEFECT LIABILITY PERIOD, or if applicable the extended DEFECT LIABILITY PERIOD shall be extended by any period wherein the PLANT cannot be used by reason of the CONTRACTOR putting the PLANT into such condition that it passes any relevant performance test or attempting to do so.

18.0 PERFORMANCE TESTS
18.1 The performance tests to be carried out on the PLANT shall those specified in Technical, Section VI-8.0 of NIT.

18.2 The performance test shall be carried out by the CONTRACTOR in the presence of OWNER/PMC.

The CONTRACTOR shall give a notice to the EIC/OWNER his readiness to carry out the performance tests, including a proposal for the time at which the tests would commence. The CONTRACTOR shall then confirm, at least fifteen (15) DAYS before the commencement of the performance tests.

18.3 Every performance test shall be carried out to completion unless the EIC or the CONTRACTOR shall order it to be stopped because its continuance would be unsafe or unacceptable to either party.

18.4 If PGTR fails due to any reason CONTRACTOR has to make necessary adjustments and modifications and take all remedial measures at his own cost and demonstrate PGTR.

The OWNER shall permit to CONTRACTOR to make adjustments and modifications to any part of the Plant before the repetition of any performance test.

The CONTRACTOR shall submit details of the adjustments and modifications which he proposes to make.

18.5 If any performance test is stopped before its completion, due to reasons attributable to OWNER, such test shall be repeated as soon as practicable thereafter. However, the OWNER shall have the option to operate the plant in accordance with the Operating Manuals provided by CONTRACTOR, whereupon care and custody of the PLANT shall pass on to the OWNER and DEFECT LIABILITY PERIOD shall start. The OWNER shall exercise the option to allow CONTRACTOR to carry out the Performance Tests with grant of extension of time by such number of days of deferment. Such deferment shall not exceed more than 90 days. In case the deferment exceeds 90 days, the Owner shall reimburse the additional cost of remobilisation incurred due to such deferment. However, the outer limit of such deferment shall be 12 months from COMMISSIONING and the provisions of Clause 16 shall apply thereafter. If the PLANT fails to pass any performance test, such test shall, subject to Sub-clause 18.7, be repeated as soon as practicable thereafter. The OWNER shall permit to CONTRACTOR to make adjustments and modifications to any part of the Plant before the repetition of any performance test and shall, if the CONTRACTOR reasonably requires, shut down any part of the PLANT for such purpose and restart it after completion of the adjustments and modifications, which shall be made by the CONTRACTOR with all reasonable speed.

The timing of such shutdown shall be agreed between the CONTRACTOR and the EIC, provided that if any or both i.e. the timing of shutdown or repetition of Performance Test, is required to be deferred, the agreed period of Performance Test Period shall be accordingly extended.
The CONTRACTOR shall, if so required by the EIC, submit to the EIC for his information details of the adjustments and modifications which he proposes to make.

The CONTRACTOR shall make such adjustment and modifications at his own cost.

18.6 The result of the performance tests shall be compiled by the CONTRACTOR and to be submitted to OWNER/PMC for evaluation.

18.7 If the PLANT passes performance tests towards meeting all Performance Guarantees specified at Section VI-8.0 (TECHNICAL) of NIT, but does not pass the performance test towards meeting Works Guaranteed cost for reasons which are the responsibility of the CONTRACTOR, then

i) If, the results of the performance tests towards meeting Guaranteed Works Cost are within the limits for the application of MUTUALLY AGREED DAMAGES, CONTRACTOR shall at its option either:

   (a) may carry out remedial measures necessary to attain the Guaranteed Works Cost and repeat the performance test; or

   (b) pay the applicable MUTUALLY AGREED DAMAGES in terms of clause 31 GCC.

Upon payment or allowance of such sum the CONTRACTOR shall become entitled to PRELIMINARY ACCEPTANCE CERTIFICATE which shall inter alia state that applicable MUTUALLY AGREED DAMAGES have been paid in respect of shortfall in performance and CONTRACTOR shall be released from all liability with respect to PGTR.

Further, in case of a) above, the CONTRACTOR will be allowed only one more chance to pass the performance test.

ii) If the results of the performance tests towards Guaranteed Works Cost are outside the limits for application of MUTUALLY AGREED DAMAGES specified in the CONTRACT, OWNER may at his option:

   a) instruct the CONTRACTOR to investigate or to co-operate with the EIC or others in the investigation of the reasons in its WORK for the shortfall in the performance;

   b) instruct the CONTRACTOR to propose remedial measure and work necessary to correct the shortfall whether as the result of any such investigation or not;

   and/or
c) Recommend the CONTRACTOR to carry out, at CONTRACTOR’S option, whatever remedial measures and work within its scope of WORK may be necessary to correct the shortfall.

Thereafter the EIC or CONTRACTOR may require that the PERFORMANCE GUARANTEE TEST RUN be repeated, the result of which shall be subject to this Sub-clause 18.7 (i).

The CONTRACTOR shall bear his own cost of work undertaken in accordance with (a), (b) or (c) above.

iii. After 3 (three) failed Performance Tests as specified at Technical Section VI-8.0 of NIT for reasons attributable to the CONTRACTOR, the OWNER shall have right to proceed with the encashment of Contract Performance Security, pursuant to Clause 34.2 of GCC.

19.0 FINAL ACCEPTANCE CERTIFICATE

19.1 As soon as DEFECT LIABILITIES PERIOD for the PLANT has expired or the CONTRACTOR has made good all DEFECTS that have within such period appeared in the PLANT in accordance with Clause 17 (Liability for Defects), whichever is later, the EIC shall issue a FINAL ACCEPTANCE CERTIFICATE to the CONTRACTOR stating that the PLANT has been finally accepted.

19.2 The FINAL ACCEPTANCE CERTIFICATE shall constitute conclusive evidence for all purposes and in any proceedings whatsoever between the OWNER and the CONTRACTOR that the CONTRACTOR has completed the PLANT and made good all DEFECTS therein in all respects in accordance with his obligations under the CONTRACT.

No FINAL ACCEPTANCE CERTIFICATE shall be conclusive as stated above if FINAL ACCEPTANCE CERTIFICATE was issued in reliance upon any fraudulent act, misrepresentation or concealment.

20.0 TAXES AND DUTIES

20.1 Notwithstanding anything mentioned regarding Taxes and Duties in Instruction to Bidders, General conditions of Contract, aforementioned provisions of Special Conditions of Contract, or any other portion of NIT, following shall apply under this LSTK Contract. However, all other terms of Instruction to Bidders, General conditions of Contract, and Special Conditions of Contract, so far as they are not superseded by introduction of GST, shall remain unchanged:

“Goods and Services Tax” or “GST” means taxes or cess levied under the Central Goods and Services Act, Integrated Goods and Service Tax Act, Goods and Services Tax (Compensation to States) Act, and various State / Union Territory Goods and Services Tax Laws and applicable cesses, if any under the laws in force (hereinafter referred to as relevant GST laws) w.e.f. 01.07.2017, which shall be fully complied with by Bidders.
The prices shall include all duties, taxes and levies etc. including but not limited to customs duty, GST on imports, any tax / duty/ levy as per applicable GST laws, personnel and corporate tax as applicable. It is clarified that Bidder is required to include the Building and Other Construction Workers Welfare Cess (BOCW) cess, as applicable, in the bid price. Owner shall deduct the aforesaid cess from the running payments and pay this cess directly to the applicable authorities.

Due input Tax credits under GST as per the relevant Govt. Policy wherever applicable, shall be taken into account by the Bidder while quoting his prices. Provision of GST law in respect of Related Persons / Parties may appropriately be taken into consideration by Bidders while submitting their bids.

The Bidders are to quote firm prices. In respect of both direct transaction between OWNER and the Bidder and Bought Out Items to be dispatched directly from the sub-vendor's works to Owner's site, the payment towards all applicable Indian Taxes and duties like Custom Duty, GST and other tax/duty/levy, will be made by OWNER in Indian rupees at actuals limited to the amount indicated in the Bid.

In case of Bought out items to be dispatched directly from sub-vendor's works to Owner's site, the CONTRACTOR shall ensure that his sub-vendors raise tax invoice under the provisions of GST Law, billed to the CONTRACTOR and shipped to Owner's site. The CONTRACTOR shall further ensure that he raises his corresponding tax invoices under the provision of GST Law in the name of OWNER during transit of the Material before the delivery of Material is taken by OWNER.

Notwithstanding anything to contrary contained in the agreement / Purchase Order, Contractor's right to payment under the Contract / agreement / Purchase Order is subject to issuance of valid tax invoice, payment of applicable GST to the credit of appropriate Government and submission of valid particulars of tax invoice under GST returns in accordance with GST act.

CONTRACTOR shall issue tax invoices, file appropriate returns, and deposit the applicable GST to the account of appropriate Government within the time limit prescribed under the GST Law. In the event of any default, CONTRACTOR shall be liable to pay the amount, if so imposed on Owner due to such default.

CONTRACTOR should comply with the provisions of e-way bill notified by appropriate authorities from time to time. The existing provisions of road permit will continue till such time if applicable.

OWNER will deduct GST at source at the applicable rates in case transactions under the CONTRACT are liable to GST deduction at source as per the prevailing provisions of GST Law.
If OWNER is required to pay any quoted Tax / Duty on reverse charge basis, same shall be paid by OWNER directly to tax authorities and deducted from the respective head of Taxes and Duties quoted in the bid.

20.2 Further, Section 171 of CGST Act, 2017 provides that “any reduction in rate of tax on any supply of goods or services or the benefit of input tax credit shall be passed on to the recipient by way of commensurate reduction in prices”. Accordingly, Bidders are required to ensure compliance to the anti-profiteering clause under GST law.

20.3 There will be no materials under the scope of Contract which will be consigned to Owner, unless otherwise specifically mentioned elsewhere in the tender. The Owner will not issue / provide Road permits/e-way bill to the Contractor except in respect of material directly purchased by the Owner.

21.0 GST

21.1 If, any delay is arising in payment against the invoice due to fault of supplier and any reversal of input tax arises due to delay payment of invoice the same will be recovered from supplier along with interest as paid by OWNER due to reversal.

21.2 In case the GST rating of vendor on the GST portal / Govt. official website is negative / black listed at any stage even after supplier order /award of work issued, OWNER has right to reject the supply order/letter of award. OWNER shall not be obligated or liable to pay or reimburse GST to such vendor and shall also be entitled to deduct / recover such GST along with all penalties / interest, if any, incurred by OWNER.

21.3 In case CBIC (Central Board of Indirect tax and Customs)/ any equivalent government agency brings to the notice of OWNER that the Supplier of Goods has not remitted the amount towards GST (CGST & SGST/UTGST or IGST) collected from OWNER or any other person to the government exchequer, OWNER reserve the right to upload such defaulter on website and may also consider for giving holiday/debarring from participating tenders.

21.4 The amount of Statutory levies like, CGST, SGST & IGST will be released when the same will appear in the GSTR-2A of OWNER, in the common portal of GST and after submission of documentary evidence of the deposition of GST taxes and filing of GST returns. If, input tax credit is not available to OWNER for any reason attributable to the bidder, then OWNER shall not be obligatory or liable to pay or reimburse Custom Duty/ GST claimed in invoice and shall be entitled to deduct /setoff/ recover such custom duty and/or GST together with all the penalty and interest if any, against any paid or payable to bidder. Further in this case, OWNER reserves the right to upload the name of such defaulter on the Company website and may also consider for giving Holiday or debarred from participation in future tender.

21.5 Contractor declares that:
1. CONTRACTOR shall ensure timely submission of invoice(s) as per rules/regulations of GST (section 31 of CGST Act 2017 along with rule 46 & 47 of CGST Rule, 2017) with all required supporting document(s) within a period specified in Contracts/ LOA to enable TFL to avail input tax credit. Further, returns and details required to be filled under GST laws & rules should be timely filed by supplier with requisite details.

2. CONTRACTOR would promptly pay GST, as per law, for the supplies made to TFL and would upload returns within the prescribed time to enable TFL, to avail the input tax credit [ITC].

3. All necessary adjustment vouchers such as Credit Notes / Debit Notes for any short/excess supplies or revision in prices or for any other reason under the Contract shall be submitted to TFL as per GST provisions.

4. In the event of default on his part in payment of tax and submission / uploading of monthly returns, TFL is well within its powers to withhold payments, especially the tax portion, until CONTRACTOR corrects the default and / or complies with the requirements of GST and produces satisfactory evidence to that effect or upon GST appearing on the Company GST portal.

5. If, as a result of any delay or default on his part, TFL, is rendered unable to avail ITC, he would, at his own cost, get the shortcoming rectified in the return to be filed immediately thereafter.

6. In case GST credit is delayed/ denied to TFL reversed subsequently as per GST law, due to non/delayed receipt of goods and/or services and/or tax invoice or expiry of timeline prescribed in GST Law for availing such ITC, non-payment of taxes or non-filing of returns or any other reason not attributable to TFL, GST amount shall be recoverable from CONTRACTOR along with interest levied/ leviable on TFL.

7. In the event of delay getting ITC to TFL, due to reasons attributable to the CONTRACTOR, TFL, reserves the right to recover interest at 12% on the tax credit so available for the number of days the ITC was delayed. TFL may recover such amount from the Security Deposit or any such Deposit / Credit Balance / future payments. Accordingly, TFL will raise Invoice/Debit note on the CONTRACTOR.

8. TFL reserves the right to suspend / cancel / terminate the contract in the event of frequent / multiple / repeated defaults by the CONTRACTOR in complying with the above requirements as per GST and CONTRACTOR shall be put under Holiday list as mentioned in the Contract.

9. Advance payments: CONTRACTOR should issue Receipt vouchers immediately on receipt of advance payment and subsequently issue supplies along tax invoice after adjusting advance payments as per Contractual terms and GST Provisions.
10. Anti-profiteering: CONTRACTOR agrees unconditionally that any benefit arising, either directly or indirectly, out of implementation of GST is mandatorily passed on to TFL.

11. Any GST liability arising on TFL under reverse charge before actual receipt of goods and or services and/or invoice thereof would be subject to recovery of interest leviable for the period between the date of such liability and actual date of eligibility of ITC based on receipt of goods, receipt of invoices and other conditions specified in GST law, as applicable.

12. Any late delivery i.e., delivery after the due date attracts payment of damages by the vendor / contractor as agreed mutually. It is agreed by the Contractor that such damages become recoverable by TFL with applicable GST thereon.

13. Contractor will give an undertaking on invoice or as separate annexure along with invoice in following format; “Applicable GST returns has been/ will be uploaded in GST Portal with due time as prescribe in CGST Act and CGSAT, SGST or IGST has been deposited as per provisions of GST Act and rules thereon”.

22. COMPLETION PERIOD:

Completion Period shall be 26 (Twenty Six) months reckoned from date of issuance of FAX OF ACCEPTANCE (FOA). Successful COMMISSIONING of plant shall be considered as date of completion.
SECTION: VI - 1.0

PROJECT DESCRIPTION

PLANT : STEAM GENERATION PLANT

PROJECT : INTEGRATED COAL BASED FERTILISER
          & CHEMICAL COMPLEX AT TALCHER,
          DISTRICT –ANGUL ODISHA (INDIA)
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1.0 INTRODUCTION

Talcher Fertilizers Ltd. (TFL), hereinafter also referred to as “OWNER” A joint venture company of four major Public Sector Units – M/s GAIL (India) Limited (GAIL), M/s Rashtriya Chemicals & Fertilisers Ltd. (RCF), M/s Coal India Ltd. (CIL) and M/s Fertilizers Corporation of India Ltd. (FCIL) has decided to build a world class coal based fertilizer complex at Talcher, Angul District, Odisha (India) consisting of Coal Gasification Plant, Ammonia and Urea Plant, along with other associated Offsite and Utility Plants. To cater the requirement of steam for the above plants, TFL intends to set up a coal based “Steam Generation Plant” under one LSTK package. Accordingly, TFL intend to invite quotations from eligible contractors on LSTK basis for setting-up a coal based “Steam Generation Plant”.

1.1 Projects & Development India Ltd. (PDIL) has been retained by M/s TFL as a Project Management Consultant for selection of a suitable LSTK Contractor for execution of the project on a Lump-Sum Turnkey basis with Single point responsibility.

1.2 LSTK CONTRACTOR is advised to visit and examine the site conditions and obtain the necessary information/ inputs on its own responsibility that may be necessary for preparing their bid and entering into the Contract. Claims of any kind due to variation or ignorance of site and environmental conditions will not be eligible and entertained by TFL under in any circumstances.

2.0 PLOT AREA

Steam Generation Plant shall be built in the earmarked area as shown in the overall site plan for Talcher Project (Refer: Attachment-1, Drawing No.PC009-0000-0001). LSTK CONTRACTOR should ensure that the available area should be used in the most optimum way.

2.1 Plant Site

A brief status of infrastructure at Talcher Fertiliser Plant Site is furnished below:

- The proposed project will be located within the existing premises of proposed Coal gasification based Fertilizer Complex, Talcher Fertilizer Limited at Talcher, Angul, Odisha.

- The total land area of the site is 933.60 acres and out of which lease hold land from Government of Odisha is 923.27 acres and land purchased from private parties is 10.33 acres.

The area is not falling under coal bearing zone up to a depth of 200-250 meter. FCIL had a full fledged fertilizer complex of Ammonia-Urea plants at this site which was in operation for over a period of 25 years and closed down since December 2002. The old abandoned plant machinery, building, facilities etc have been demolished and removed from site. LSTK Contractor shall carry out the soil investigation study for the selected area for the project within existing premises. However, for reference purpose only, please see attached Soil Investigation Report.
Talcher site is located at Vikrampur in Angul district of Odisha on the Cuttack – Sambalpur National Highway NH-42. NH-42 is passing at about 8 km from the site. The nearest railway station is Talcher which is at about 7 km from the site. Nearest air port Bhubaneswar is about 150 km, about 3 hours journey by road/ rail. Nearest sea port is Paradip, 200 km by rail/road from the site. Talcher is situated at 21° 10” N Latitude and 82° 5” E Longitude.

2.2 PLANTS & ASSOCIATED FACILITIES

The plant would essentially consist of Steam Generation Plant and its associated facilities. The LSTK Contractor shall consider for installation of all the relevant facilities of appropriate capacity as necessary for smooth, safe and reliable operation of the plants.

a. Plants Capacity & Configuration

The Steam Generation Plant (SGP) consists of 3 Nos of boilers with configuration of 2W+1S. Normal Continuous Run (NCR) & Maximum Continuous Run (MCR) of each boiler to be decided by vendor considering export of steam as specified in Section-VI-4.0 Clause No. 2, point no. a & b after meeting all internal steam consumption requirements of Steam Generation Plant. SGP shall have provision of additional steam superheating coils to cater the HP saturated steam received from Ammonia plant for superheating in Steam Generation plant battery limit. For further details, refer Section-VI-4.0.

b. De-aerators

One common De-aerator is proposed for Boilers. Required steam for De-Aeration shall be arranged within internal resources of SGP.

De-mineralised Water (DMW) shall be supplied by owner at the plant B.L 2 months before scheduled completion period.

Boiler Feed Water Pumps

BFW Pumps and associated pipings & systems are proposed as per Section-VI-4.0 (Process Design Basis). Drive of BFW pumps shall meet the stipulations of IBR regulation in force.

c. Gaseous effluents

Flue Gas generated in the Boilers shall contain SOx, NOx, un-burnt combustibles, dust particles, etc. and shall be discharged to atmosphere through dedicated chimneys after necessary abatement/treatment to meet the latest statutory requirement / guidelines.

d. Ash Handling System

Ash generated in all the Boilers (both Bottom ash and Fly ash) shall be transported suitably from Boiler area to the dedicated Bottom Ash / Fly Ash Storage Silo near Ash Pond by LSTK bidder. Further, Refer Section-VI-5.3.4.
e. Plant and Instrument air system

Plant and Instrument air will be provided by Owner 2 months before scheduled completion period of SGP at single point tie-in connection at the battery limit of LSTK Contractor. Required Plant & Instrument air in the above period (2 months before scheduled completion period) shall be arranged by LSTK Contractor himself. Proper instrument air storage (15Min.) & Instrument air distribution network shall be provided for the SGP by LSTK contractor within their B.L. Please refer Section-VI-2.0 of Part-II Technical for plant and instrument air specification.

f. Natural Gas

For start-up of Boilers, Natural gas shall be provided Owner 2 months before scheduled completion period at battery limit of LSTK Contractor. However further necessary arrangement for supply, control and distribution shall be in the scope of LSTK Contractor.

g. Control Room for Steam Generation Plant

Control Room shall be located within the battery limit (B.L) of SGP. Minimum two no. common goods cum passenger industrial Lift of min. Two tonne Capacity up to boiler upper drum level to take care of operation & maintenance activities is also required. Lifts shall cover all the floor levels. Interconnection platform at alternate floors among boilers shall also be provided. The integrated Control Room shall be provided for all the boilers and associated system of Steam Generation Plant.

h. Interconnecting Piping

All interconnecting piping between LSTK Battery Limit and balance of plants shall be under Owner’s scope. Owner shall provide Make-up DM Water, Condensate, Process Water/Service Water, Cooling water, Saturated HP Steam for superheating, Plant Air/Instrument Air, Inert Gas, Fire Water etc., at Steam Generation plant battery limit.

i. Dust suppression system

Adequate Dust Suppression System shall be considered by LSTK Contractor in the plant to maintain a dust free atmosphere within the plant as per latest statutory requirement to meet ambient air quality standard. NOISE level shall be within the limits stipulated by CPCB/OSPCB, whichever is more stringent.

j. Fire Fighting System

All requirement of fire fighting system inside Steam Generation plant shall be as per NFPA standards with due approval from relevant authorities are in LSTK Contractor’s scope. LSTK Bidder shall indicate fire water requirement in their bid which shall be supplied at a given point at the battery limit.

k. Temporary Construction Facilities

The LSTK shall arrange following facilities at his own cost for Construction/Erection purpose.

   1. 1 No. 11 kV Feeder (rated for 2 MVA) at Existing Substation near 132 KV Switchyard shall be made available. Tapping of Construction Power (on chargeable basis) from this feeder
(including supply & erection of all required materials like structural supports for cable tray, cable trays, power cables, control cables, protection & metering, cable termination etc. as well as underground cabling work) and further distribution shall be in LSTK Contractor’s scope.

2. Construction Water on chargeable basis (at one point within factory premises and CONTRACTOR to arrange the pipeline up to their Battery Limit) shall be made available

3. Construction sheds

4. Construction offices

5. Temporary Communication facilities

6. Office furniture

7. Labor colony during construction

8. Temporary stores & security
SECTION: VI - 2.0

RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS

PLANT: STEAM GENERATION PLANT

PROJECT: INTEGRATED COAL BASED FERTILISER COMPLEX AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA)
## CONTENTS

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<th>Sheet Number</th>
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</thead>
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<td>3</td>
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<tr>
<td>3.0</td>
<td>Utilities</td>
<td>3</td>
</tr>
<tr>
<td>4.0</td>
<td>Specification of Product</td>
<td>7</td>
</tr>
</tbody>
</table>

## LIST OF ATTACHMENT

<table>
<thead>
<tr>
<th>Attachment number</th>
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<th>Number of Sheets</th>
</tr>
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<td>2</td>
<td>Annexure-2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Annexure-3</td>
<td>1</td>
</tr>
</tbody>
</table>
1.0 RUN OF MINE (ROM) COAL
Specification of ROM Coal fed to Steam Generation plant for production of HP Super heated steam is attached herewith (refer Annexure-1). However, typical Coal analysis (proximate & ultimate) is furnished below:

Works cost Guarantee shall be as per below Table-1.0. However, Boiler should be designed based on range of the Coal Analysis given in Annexure-1.

Table:-1.0

<table>
<thead>
<tr>
<th>Description</th>
<th>Raw Coal at B.L. of SGP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proximate Analysis</strong></td>
<td></td>
</tr>
<tr>
<td>Moisture, %wt</td>
<td>14.77</td>
</tr>
<tr>
<td>Ash, %wt</td>
<td>43.5</td>
</tr>
<tr>
<td>Volatile, %wt</td>
<td>25.75</td>
</tr>
<tr>
<td>Fixed Carbon, %wt</td>
<td>25.75</td>
</tr>
<tr>
<td>Fluidity point, C</td>
<td>&gt;1400</td>
</tr>
<tr>
<td>HHV MJ/kg, given MF 1 4)</td>
<td>16.81</td>
</tr>
<tr>
<td><strong>Ultimate Analysis (MAF basis)</strong></td>
<td></td>
</tr>
<tr>
<td>Carbon, %wt</td>
<td>79.66</td>
</tr>
<tr>
<td>Hydrogen, %wt</td>
<td>5.30</td>
</tr>
<tr>
<td>Oxygen, %wt</td>
<td>12.60</td>
</tr>
<tr>
<td>Chloride, %wt</td>
<td>0.01</td>
</tr>
<tr>
<td>Sulfur, %wt</td>
<td>0.66</td>
</tr>
<tr>
<td>Nitrogen, %wt</td>
<td>1.78</td>
</tr>
<tr>
<td>LHV (lower heating value) ,Kcal/kg</td>
<td>3200</td>
</tr>
</tbody>
</table>

Size of Coal: - Refer Section-VI-5.3.4

2.0 Fluxant (If required)
Purity 85 wt. % (Min.)
Appearance: Powder/ Solid Lumps

Size of Fluxant: - Refer Section-VI-5.3.4

3.0 UTILITIES

<table>
<thead>
<tr>
<th>3.1 Cooling Water (UNDER OWNER’S SCOPE)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Header Pressure, kg/cm²g (Min/ Nor/ Max) at B.L.</td>
<td>2.5/3.5/4.0</td>
</tr>
<tr>
<td>Return Header Pressure, kg/cm²g (Min/ Nor/ Max) at B.L.</td>
<td>-2.5/-</td>
</tr>
<tr>
<td>Mechanical Design Pressure, kg/cm²g</td>
<td>8.0</td>
</tr>
<tr>
<td>Supply Header Temperature, °C</td>
<td>33</td>
</tr>
<tr>
<td>Return Header Temperature, °C</td>
<td>By LSTK Contractor</td>
</tr>
<tr>
<td>Mechanical Design Temperature, °C</td>
<td>70</td>
</tr>
<tr>
<td>Design wet Bulb temperature ,°C</td>
<td>29.0</td>
</tr>
<tr>
<td>ΔT</td>
<td>10 °C max.</td>
</tr>
<tr>
<td>Relative Humidity at Talcher</td>
<td>100% (max.)</td>
</tr>
</tbody>
</table>
### Analysis of Cooling Water

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.5-7.5</td>
</tr>
<tr>
<td>Conductivity, µ mho/cm</td>
<td>500</td>
</tr>
<tr>
<td>Total Alkality as CaCO₃, ppm</td>
<td>300 max.</td>
</tr>
<tr>
<td>P. Alkality as CaCO₃, ppm</td>
<td>Nil</td>
</tr>
<tr>
<td>Total Hardness as CaCO₃, ppm</td>
<td>1000 max.</td>
</tr>
<tr>
<td>Ca Hardness as CaCO₃, ppm</td>
<td>500 max.</td>
</tr>
<tr>
<td>Mg Hardness as CaCO₃, ppm</td>
<td>550 max.</td>
</tr>
<tr>
<td>Chloride as Cl, ppm</td>
<td>300 max.</td>
</tr>
<tr>
<td>TDS, ppm</td>
<td>2800 max.</td>
</tr>
<tr>
<td>Total iron as Fe, ppm</td>
<td>1 max.</td>
</tr>
<tr>
<td>Corrosion Rate, ppm</td>
<td>&lt; 1.5 MPY</td>
</tr>
<tr>
<td>Silica as SiO₂, ppm</td>
<td>125 max.</td>
</tr>
<tr>
<td>Nitrate as NO₃, ppm</td>
<td>300 max.</td>
</tr>
<tr>
<td>Sulphate as SO₄, ppm</td>
<td>800 max.</td>
</tr>
<tr>
<td>SRB count</td>
<td>&lt; 20 per 100 ml.</td>
</tr>
<tr>
<td>Total Suspended solids (TSS)</td>
<td>&lt; 25</td>
</tr>
<tr>
<td>Manganese as Mn</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Free Chlorine, ppm</td>
<td>0.2-0.4</td>
</tr>
<tr>
<td>Phosphate as PO₄ (Orth), ppm</td>
<td>7-11</td>
</tr>
<tr>
<td>Total Phosphate, ppm</td>
<td>8-14</td>
</tr>
<tr>
<td>Turbidity, NTU</td>
<td>&lt; 10</td>
</tr>
</tbody>
</table>

### 3.2 Nitrogen (Utility) UNDER OWNER’S SCOPE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure, kg/cm²g (Min/Nor/Design)</td>
<td>6.0/8.0/9.0</td>
</tr>
<tr>
<td>Temperature</td>
<td>Ambient</td>
</tr>
<tr>
<td>N₂, Vol %, min</td>
<td>99.99%</td>
</tr>
<tr>
<td>O₂, Vol ppm</td>
<td>&lt; 10</td>
</tr>
</tbody>
</table>

### 3.3 Instrument Air UNDER OWNER’S SCOPE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure, kg/cm² g</td>
<td>6.0</td>
</tr>
<tr>
<td>Supply Temperature, °C</td>
<td>Ambient</td>
</tr>
<tr>
<td>Mech. Design Temperature, °C</td>
<td>65</td>
</tr>
<tr>
<td>Dew point</td>
<td>-40 °C at atm. Pressure</td>
</tr>
<tr>
<td>Quality</td>
<td>Free of dust, water drops &amp; oil</td>
</tr>
<tr>
<td>High pressure storage vessel with compressor &amp; necessary arrangement for safe shut-down (Under LSTK Contractor’s Scope)</td>
<td>Min. 15 minute</td>
</tr>
</tbody>
</table>

### 3.4 Demineralised Water UNDER OWNER’S SCOPE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure @ B/L, kg/cm²g (Min/ Nor/ Max)</td>
<td>4.0/ 5.5/ 6.0</td>
</tr>
<tr>
<td><strong>Temperature, °C (Normal)</strong></td>
<td>Ambient/ 40 (max) *</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td><strong>Mech. Design Pressure, kg/cm²g</strong></td>
<td>10</td>
</tr>
<tr>
<td><strong>Mech. Design Temperature, °C</strong></td>
<td>70</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>6.5-8.5</td>
</tr>
<tr>
<td><strong>Total Hardness, ppm wt.</strong></td>
<td>Zero</td>
</tr>
<tr>
<td><strong>Total Dissolved Solids, ppm wt (max.)</strong></td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Conductivity at 20 deg C, micro mho/cm (max.)</strong></td>
<td>&lt;0.2</td>
</tr>
<tr>
<td><strong>M Alkinity as CaCO₃, ppm wt.</strong></td>
<td>Nil</td>
</tr>
<tr>
<td><strong>Chlorides, ppm wt.</strong></td>
<td>Nil</td>
</tr>
<tr>
<td><strong>Iron as Fe, ppm wt. (max.)</strong></td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Silica as SiO₂, ppm wt. (max.)</strong></td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Oil, ppm wt.</strong></td>
<td>Nil</td>
</tr>
<tr>
<td><strong>Sodium as Na, ppm wt. (max.)</strong></td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td><strong>Dissolved Oxygen (Saturated) mg/l</strong></td>
<td>6.5</td>
</tr>
</tbody>
</table>

* LSTK Contractor should study for DM water to be available at 89°C

### 3.5 Boiler Feed Water UNDER LSTK CONTRACTOR’S SCOPE

| **Total Hardness as CaCO₃, mg/l** | Nil |
| **O₂, mg/l** | <0.005 |
| **Silica as SiO₂, mg/l** | < 0.2 |
| **pH (at 25 deg. C)** | 8.5-9.5 |
| **Conductivity, µS/cm (at 25°C before pH adjustment with NH₃)** | < 0.3 |
| **Oil, ppm** | Nil |
| **Fe +Cu  mg/lt.** | <0.01 |
| **Residual Hydrazine (as N₂H₄) Mg/l** | <0.05 |
| **Oxygen consumed in 4 hours, mg/l** | Nil |

### 3.6 Boiler Blow Down (Boiler CBD) UNDER LSTK CONTRACTOR’S SCOPE

| **pH** | 9.0-11.0 |
| **Silica as SiO₂, ppm** | < 0.5 |
| **Conductivity, µS/cm** | < 50 |
| **Phosphate, ppm** | 2-5 |

### 3.7 Process Water/ Raw water (after treatment) UNDER OWNER’S SCOPE

<p>| <strong>pH</strong> | 7 – 8.5 |
| <strong>Chlorides, mg/l</strong> | 20 |
| <strong>Sulphates, mg/l</strong> | - |
| <strong>Silica, mg/l</strong> | 5 |
| <strong>Iron, mg/l</strong> | 0.2 |
| <strong>Manganese, mg/l</strong> | - |
| <strong>Total Suspended Solids, mg/l</strong> | 5 |
| <strong>Total Dissolved Solids, mg/l</strong> | 100 |</p>
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil &amp; Grease, mg/l</td>
<td>Traces</td>
</tr>
<tr>
<td>Ammonia, mg/l</td>
<td>Traces</td>
</tr>
<tr>
<td>Alkany, mg/l as CaCO₃</td>
<td>68</td>
</tr>
<tr>
<td>Calcium Hardness, mg/l as CaCO₃</td>
<td>100</td>
</tr>
<tr>
<td>Total Hardness, mg/l as CaCO₃</td>
<td>150</td>
</tr>
<tr>
<td>Supply Pressure, kg/cm²g (Min/ Nor/ Max)</td>
<td>4/ 6/ 8</td>
</tr>
<tr>
<td>Supply Temperature, deg C</td>
<td>Ambient</td>
</tr>
<tr>
<td>Mechanical Design Pressure, kg/cm²g</td>
<td>10.5</td>
</tr>
<tr>
<td>Mechanical Design Temperature, deg C</td>
<td>65</td>
</tr>
</tbody>
</table>

### 3.8 Drinking Water UNDER OWNER'S SCOPE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>&lt; 5.0</td>
</tr>
<tr>
<td>Smell</td>
<td>Agreeable</td>
</tr>
<tr>
<td>pH</td>
<td>7.0-7.5</td>
</tr>
<tr>
<td>Taste &amp; Odour</td>
<td>Unobjectionable</td>
</tr>
<tr>
<td>TDS, mg/l</td>
<td>&lt; 150</td>
</tr>
<tr>
<td>Turbidity, NTU</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Total Hardness, mg/l</td>
<td>&lt; 85</td>
</tr>
<tr>
<td>Chloride (as Cl), mg/l</td>
<td>&lt; 15</td>
</tr>
<tr>
<td>Sulphate (as SO₄), mg/l</td>
<td>&lt; 60</td>
</tr>
<tr>
<td>Total Iron (Fe), mg/l</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Dissolved Silica, mg/l</td>
<td>&lt; 4</td>
</tr>
<tr>
<td>Supply Pressure, kg/cm²g (Min/ Nor/ Max)</td>
<td>4/ 5.5/ 6.0</td>
</tr>
<tr>
<td>Supply Temperature, deg C</td>
<td>Ambient</td>
</tr>
<tr>
<td>Mechanical Design Pressure, kg/cm²g</td>
<td>12.5</td>
</tr>
<tr>
<td>Mechanical Design Temperature, deg C</td>
<td>65</td>
</tr>
</tbody>
</table>

Note: Drinking water of quality conforming to IS: 10500-1991 shall be provided by the Owner to LSTK Contractor at the Battery Limit.

### 3.9 Plant Air UNDER OWNER'S SCOPE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>Saturated</td>
</tr>
<tr>
<td>Design Dew Point</td>
<td>Ambient</td>
</tr>
<tr>
<td>Oil Content</td>
<td>Nil</td>
</tr>
<tr>
<td>Supply Pressure, kg/cm²g (Min/ Nor/ Max)</td>
<td>4.0/7.0/8.0</td>
</tr>
<tr>
<td>Supply Temperature, deg C (Min/ Nor/ Max)</td>
<td>40/40/50</td>
</tr>
<tr>
<td>Mechanical Design Pressure, kg/cm²g</td>
<td>10.5</td>
</tr>
<tr>
<td>Mechanical Design Temperature, deg C</td>
<td>70</td>
</tr>
</tbody>
</table>

### 3.10 Fire Water **

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure kg/cm²g</td>
<td>Min. 7 (As per NFPA/TAC)</td>
</tr>
<tr>
<td>Temp. deg C</td>
<td>Ambient</td>
</tr>
</tbody>
</table>
** Fire water header of LSTK area shall be connected to Fire water ring main header of the complex. Fire water shall be in Owner scope and same shall be made available at B.L.

<table>
<thead>
<tr>
<th>3.11 NG (Under Owner Scope)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
</tr>
<tr>
<td>Pressure kg/cm²g</td>
</tr>
<tr>
<td>Temp. deg C</td>
</tr>
</tbody>
</table>

### 4.0 SPECIFICATION OF PRODUCT

#### 4.1 H.P Steam

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure, kg/cm²g (Min/ Nor/ Max)</td>
<td>107/110/112</td>
<td>130</td>
</tr>
<tr>
<td>Temperature, °C (Min/ Nor/ Max)</td>
<td>515/520/525</td>
<td>Not less than 540</td>
</tr>
<tr>
<td>Silica as SiO₂, ppm</td>
<td>&lt; 0.02</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>9-9.5</td>
<td></td>
</tr>
<tr>
<td>Conductivity, µS/cm (at 25 deg.C)</td>
<td>&lt; 0.2</td>
<td></td>
</tr>
<tr>
<td>Total Iron (Fe) mg/kg</td>
<td>&lt; 0.01</td>
<td></td>
</tr>
<tr>
<td>Na+K mg/kg</td>
<td>&lt; 0.01</td>
<td></td>
</tr>
<tr>
<td>Copper mg/kg</td>
<td>0.003</td>
<td></td>
</tr>
</tbody>
</table>

#### 4.2 Saturated H.P Steam for Superheating UNDER LSTK CONTRACTOR'S SCOPE

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure, kg/cm²g (Min/ Nor/ Max)</td>
<td>118/120/123</td>
<td></td>
</tr>
<tr>
<td>Temperature, °C (Min/ Nor/ Max)</td>
<td>322/323/325</td>
<td></td>
</tr>
</tbody>
</table>

#### 4.3 L.P Steam (Available by LSTK Contractor at Plant B.L.)

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure, kg/cm²g (Min/ Nor/ Max)</td>
<td>3.5/4.0/4.5</td>
<td>6.0</td>
</tr>
<tr>
<td>Temperature °C (Min/ Nor/ Max)</td>
<td>* /180/ *</td>
<td>250</td>
</tr>
<tr>
<td>*LSTK Contractor to fill</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SALIENT FEATURES
OF
REVISED GEOLOGICAL REPORT ON COAL EXPLORATION IN
BHUANESHWARI BLOCK, TALCHER COALFIELD

1. Location: South eastern part of Talcher Coalfield, Angul District, Orissa.
   Longitude: 85°09'10" to 85°11'37" E
   Latitude: 20°57'50" to 20°59'42" N
   Toposheet: 73 M/1 R.F. 1:50,000
   District: Angul
   Prominent Village: Hensamul, Langijoda, Naraharipur & Kandhal.

2. Accessibility/Communication: This block is connected to NH-23 and NH-42 by all weather roads. The block is about 2 km. & 15 km. from NH-23 & NH-42 respectively. Bhubaneswar is about 153 km. from the block. Nearest railway station is Talcher (6 km.) on Cuttack-Sambalpur section of South-eastern Railway.

3. Objective: Revised assessment of coal seams in terms of their lay and disposition with the associated strata, structural framework, quality and reserves of coal available within Bhubaneswari Block.

4. Period of Investigation: Drilling of this block was done in 3 phases:
   I 1903-09 (G.R. submitted based on the data of March, 1991)
   II 1992-94 (Data generated in these 2 phases are added to earlier G.R. and revised G.R. is formulated now)
   III 1997-99

5. Status of Mining: Barring for a small abandoned quarry in the south-eastern corner of the block, the area is devoid of any mining activity within the block. No appreciable reserve would have been worked out in this small quarry.

6. Area of the block: 5.8 sq.km.

7. Details of Drilling:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Agency</th>
<th>Period of drilling</th>
<th>No. of boreholes</th>
<th>Metreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C M P D I</td>
<td>1983 - 1989</td>
<td>103</td>
<td>17167.90</td>
</tr>
<tr>
<td>a)</td>
<td>Departmental Rigs (Coring)</td>
<td>1992 – 1994</td>
<td>30</td>
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<tr>
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<td>1997 - 1999</td>
<td>4</td>
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<td></td>
<td></td>
<td>Total</td>
<td>137</td>
<td>23226.90</td>
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</table>
8. Borehole Density: 23 boreholes per sq.km.

9. Other Investigations:
   i) Mapping: Geological Mapping has not been done as the area of the block is covered by alluvial soil.
   ii) Logging: All the non-coal seams and coal cores in 137 boreholes with 23226.90m of cores have been logged visually following standard geological practices.
   iii) Sampling: In all 5,981.11m of coal cores have been packed and sampled in 67 boreholes falling within the block.
   iv) Geophysical Logging: Borehole geophysical logging has been done in 9 boreholes with 2,010.10m.
   v) Surface Geophysics: No surface geophysical studies have been conducted in these 3 phases of drilling operations.
   vi) Remote Sensing: Not within the purview of present investigation.
   vii) Rock Mechanics: Studies not undertaken in this block. However, results of such studies from borehole CMTL-151 falling in adjacent Lingraj block have been presented for reference.
   viii) Hydrogeology: Hydrogeological studies were not been done. However, summary and conclusions of report "Hydrology of Talcher Coalfield (East), Dhenkanal District, Orissa (January, 1988)" submitted by CMPDI (HQ) are presented.

10. Geological Formations: Entire area is covered by paraker formation rocks and coal seams occurring within them.

11. Geological Structure:
    This block is a horst between fault F1-F1 (F11-F11 of Lingraj block) on the southern side and faults F16-F16 & F17-F17 on the northern side having away with throws of >100m.
    Dip: The general dip is 4° to 5° towards east and northeast with local variation ranging from 2° to 7°. In south-eastern part there is reversal of dip direction to northwesterly/west.
    Strike: The general strike of the beds is WNW-ESE to NW-SE with minor local wrappings. In eastern part NW-SE strikes are also seen.

12. Faults: There are 17 no. of faults within the block. Out of these faults, 3 faults mark the northern and southern boundaries of the block. They mostly trend in E-W - NNW-SSE to NW-SE. These faults have either northerly throws or southerly throws. In general, southerly dipping faults have brought the coal seams at shallow depths resulting in better quarriable potentiality.

13. Intrusives: No intrusives have been encountered within the block.
14. Coal Seams and their Quality:

<table>
<thead>
<tr>
<th>Coal Seam/Porting</th>
<th>Thickness (m)</th>
<th>Depth of Occurrence (m)</th>
<th>Proximate Analysis (at 60% RH &amp; 40°C on a dry basis)</th>
<th>Ultimate Analysis (LHV %)</th>
<th>Grade</th>
</tr>
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<tbody>
<tr>
<td>Seam-XIV</td>
<td>1.33</td>
<td>27.60</td>
<td>M % 5.1</td>
<td>A % 39.8</td>
<td>VM % -</td>
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<td>Seam-XIII</td>
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<td>12.20-39.5b</td>
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<td>A % 20.0-51.4</td>
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<td>Seam-XI</td>
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<td>10.17-104.32</td>
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<td>A % 20.5-52.1</td>
<td>VM % 21.0-30.4</td>
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<tr>
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<td></td>
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<tr>
<td>Seam-X</td>
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<td>12.45-115.65</td>
<td>M % 4.7-11.8</td>
<td>A % 16.5-44.1</td>
<td>VM % 23.6-31.8</td>
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<tr>
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<td>Seam-IX</td>
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<td>A % 27.3-62.5</td>
<td>VM % 22.3-26.6</td>
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<tr>
<td>Seam-VIII T</td>
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<td>VM % 19.2-24.0</td>
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<td>Seam-VI BT</td>
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<td>VM % -</td>
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<td>Coal Seam/Parting</td>
<td>Thickness (m)</td>
<td>Depth of Occurrence (m)</td>
<td>Proximate Analysis (at 60% RH &amp; 40°C on I₀₀₀ basis)</td>
<td>GCM (Kcal/kg)</td>
<td>UHV (Kcal/kg)</td>
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<tr>
<td>------------------</td>
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<td>------------------------</td>
<td>--------------------------------------------------</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>%M</td>
<td>A %</td>
<td>VM % (UVI %)</td>
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<td>33.0-41.8</td>
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<td>Coal Seam/Parting</td>
<td>Thickness (m)</td>
<td>Depth of Occurrence (m)</td>
<td>Proximate Analysis (at 60% RH &amp; 40°C on I_100 basis)</td>
<td>GCV (kcal/kg)</td>
<td>VM % (UVM %)</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------</td>
<td>-------------------------</td>
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<td>11.54-227.90</td>
<td>3.9-8.8 20.3-49.3 22.9-31.1 3261-5588 1476-5077</td>
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<td>4.7-9.0 26.0-47.8 24.0 29.1 3315-5134 1600-4394</td>
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<td>Seam-I 11</td>
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<td>9.6-220.39</td>
<td>4.3-0.4 25.1 14.6 25.4-29.9 3616-5599 2041-4884</td>
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<td>Seam-II + III</td>
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<td>6.0 33.9 - 4492 3394 E (F)</td>
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<td>Parting with Seam III</td>
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<td>Seam-II</td>
<td>23.21-42.18</td>
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<tr>
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<tr>
<td>Seam-II B</td>
<td>0.31-5.86</td>
<td>45.02-294.90</td>
<td>4.5 7.1 20.1-46.2 - 3553-5691 1903-5146 C-G (E-F)</td>
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<td>Seam-II B + II</td>
<td>40.51-45.76</td>
<td>161.65-190.30</td>
<td>5.2-7.0 34.4-36.0 25.4-26.7 4103-4561 2980-3435 C-G (E-F)</td>
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<td>Parting with Seam-I A</td>
<td>111.28</td>
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<tr>
<td>Seam-I A</td>
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<td>Parting</td>
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<td>Seam-I C</td>
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<tr>
<td>Seam-I E</td>
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</tr>
</tbody>
</table>

Note: i) Table 4.4 A may be consulted for better understanding of seam splits/parting.
ii) Usual Grade is given within brackets.
14.1 Seam-wise Ash Fusion and HGI Ranges:

<table>
<thead>
<tr>
<th>Coal Seam</th>
<th>Thickness (m)</th>
<th>IDT (°C)</th>
<th>HT(_1) (°C)</th>
<th>FT (°C)</th>
<th>H G I</th>
<th>Borehole considered</th>
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</thead>
<tbody>
<tr>
<td>IX</td>
<td>1.68</td>
<td>1300</td>
<td>&gt;1400</td>
<td>&gt;1400</td>
<td>58</td>
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<tr>
<td>VIII (T)</td>
<td>1.70</td>
<td>1250</td>
<td>&gt;1400</td>
<td>&gt;1400</td>
<td>54</td>
<td>CMTL-217</td>
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<tr>
<td>VII</td>
<td>6.10</td>
<td>1160</td>
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<td>&gt;1400</td>
<td>52</td>
<td>CMTL-217</td>
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<tr>
<td>VI B</td>
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<td>1400</td>
<td>&gt;1400</td>
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<td>&gt;1400</td>
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<tr>
<td>V</td>
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<td>1180-1190</td>
<td>&gt;1400</td>
<td>&gt;1400</td>
<td>53</td>
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</tr>
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<td>Local (L2)</td>
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<td>1210</td>
<td>&gt;1100</td>
<td>&gt;1400</td>
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<td>&gt;1400</td>
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<tr>
<td>L1 + IV</td>
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<td>&gt;1400</td>
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<td>CMTL-217</td>
</tr>
<tr>
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<td>&gt;1400</td>
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<td>&gt;1400</td>
<td>&gt;1400</td>
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<td>&gt;1400</td>
<td>&gt;1400</td>
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14.2 Seam-wise Ultimate Analysis Results:

<table>
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<th>Thickness (m)</th>
<th>C %</th>
<th>H %</th>
<th>N %</th>
<th>S %</th>
<th>O % (by diff.)</th>
<th>Borehole considered</th>
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</thead>
<tbody>
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<td>78.42</td>
<td>5.12</td>
<td>1.68</td>
<td>0.60</td>
<td>14.18</td>
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</tr>
<tr>
<td>VIII (T)</td>
<td>1.70</td>
<td>78.66</td>
<td>5.21</td>
<td>1.75</td>
<td>u. /2</td>
<td>13.66</td>
<td>CMTL-217</td>
</tr>
<tr>
<td>VII</td>
<td>6.10</td>
<td>79.73</td>
<td>5.26</td>
<td>1.70</td>
<td>0.52</td>
<td>13.79</td>
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<td>VI B</td>
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<td>79.24</td>
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<td>1.66</td>
<td>0.61</td>
<td>13.59</td>
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<td>VI A</td>
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<td>1.71</td>
<td>0.80</td>
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<td>V</td>
<td>11.09-13.81</td>
<td>79.24-79.63</td>
<td>5.18-5.32</td>
<td>1.75-1.86</td>
<td>0.66-0.72</td>
<td>12.61-13.03</td>
<td>CMTL-202, 217</td>
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<td>5.36</td>
<td>1.72</td>
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<tr>
<td>IV</td>
<td>11.83</td>
<td>79.23</td>
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<td>1.62</td>
<td>0.52</td>
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<td>15.69</td>
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<td>1.93</td>
<td>0.65</td>
<td>12.41</td>
<td>CMTL-202</td>
</tr>
<tr>
<td>III</td>
<td>13.28-15.14</td>
<td>79.42-79.75</td>
<td>5.26-5.29</td>
<td>1.65-1.83</td>
<td>0.58-0.72</td>
<td>12.56-12.85</td>
<td>CMTL-202, 203, 217</td>
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<tr>
<td>II B + II</td>
<td>43.84</td>
<td>79.84</td>
<td>5.36</td>
<td>1.84</td>
<td>0.73</td>
<td>12.53</td>
<td>CMTL-217</td>
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<tr>
<td>II</td>
<td>37.63</td>
<td>79.73</td>
<td>5.28</td>
<td>1.70</td>
<td>0.57</td>
<td>12.24</td>
<td>CMTL-202</td>
</tr>
</tbody>
</table>
### 14.3 Ash Analysis Results:

<table>
<thead>
<tr>
<th>Coal Seam</th>
<th>Thickness (m)</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>TiO₂</th>
<th>P₂O₅</th>
<th>MnO</th>
<th>CaO</th>
<th>MgO</th>
<th>SO₃</th>
<th>Alkalies by arr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIA</td>
<td>6.78</td>
<td>61.16</td>
<td>27.23</td>
<td>5.50</td>
<td>1.86</td>
<td>0.63</td>
<td>0.10</td>
<td>1.02</td>
<td>0.68</td>
<td>0.23</td>
<td>1.59</td>
</tr>
<tr>
<td>V</td>
<td>11.99</td>
<td>58.18</td>
<td>29.10</td>
<td>6.23</td>
<td>1.06</td>
<td>0.67</td>
<td>0.11</td>
<td>1.38</td>
<td>0.93</td>
<td>0.21</td>
<td>1.33</td>
</tr>
<tr>
<td>L2+IV</td>
<td>15.91</td>
<td>61.53</td>
<td>25.13</td>
<td>6.04</td>
<td>1.75</td>
<td>0.32</td>
<td>--</td>
<td>2.03</td>
<td>1.15</td>
<td>0.22</td>
<td>1.63</td>
</tr>
<tr>
<td>I I</td>
<td>2.17</td>
<td>60.80</td>
<td>28.52</td>
<td>4.82</td>
<td>1.86</td>
<td>0.67</td>
<td>0.02</td>
<td>1.36</td>
<td>0.93</td>
<td>0.32</td>
<td>0.70</td>
</tr>
<tr>
<td>III</td>
<td>15.14</td>
<td>62.13</td>
<td>28.10</td>
<td>4.62</td>
<td>1.70</td>
<td>0.40</td>
<td>0.00</td>
<td>0.66</td>
<td>0.62</td>
<td>0.16</td>
<td>1.10</td>
</tr>
<tr>
<td>II B+II</td>
<td>41.04</td>
<td>60.84</td>
<td>28.62</td>
<td>7.12</td>
<td>1.73</td>
<td>0.42</td>
<td>0.02</td>
<td>0.92</td>
<td>1.01</td>
<td>0.10</td>
<td>0.90</td>
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### 14.4 Cleaning Possibilities for Seams at Density Cut of 1.80:

<table>
<thead>
<tr>
<th>Coal Seam</th>
<th>Raw Coal</th>
<th>Washed Products</th>
<th>Sink</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wt %</td>
<td>Ash %</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cleans</td>
<td>Sink</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wt %</td>
<td>Ash %</td>
</tr>
<tr>
<td>VIII</td>
<td>100</td>
<td>40.0</td>
<td>57.2</td>
</tr>
<tr>
<td>VII</td>
<td>100</td>
<td>43.2</td>
<td>64.0</td>
</tr>
<tr>
<td>VI (VIIR &amp; VIA taken together)</td>
<td>100</td>
<td>51.5</td>
<td>53.0</td>
</tr>
<tr>
<td>V</td>
<td>100</td>
<td>46.0</td>
<td>63.1</td>
</tr>
<tr>
<td>IV</td>
<td>100</td>
<td>40.4</td>
<td>65.9</td>
</tr>
<tr>
<td>III</td>
<td>100</td>
<td>35.0</td>
<td>75.1</td>
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<tr>
<td>II</td>
<td>100</td>
<td>37.4</td>
<td>75.4</td>
</tr>
</tbody>
</table>

### 15. Geological Reserves:

#### 15.1 Seam-wise, Grade-wise ‘Net’ Proved Geological Reserves:

<table>
<thead>
<tr>
<th>Seam</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>Uncr</th>
<th>Total Reserves (million Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I10/II</td>
<td>-</td>
<td>1.0395</td>
<td>20.5171</td>
<td>-</td>
<td>-</td>
<td>30.5566</td>
</tr>
<tr>
<td>IIB</td>
<td>0.3026</td>
<td>2.5091</td>
<td>10.5762</td>
<td>1.3496</td>
<td>0.1405</td>
<td>14.8784</td>
</tr>
<tr>
<td>II+III</td>
<td>-</td>
<td>8.8432</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>8.8432</td>
</tr>
<tr>
<td>II</td>
<td>0.0256</td>
<td>157.2422</td>
<td>135.2794</td>
<td>0.5152</td>
<td>-</td>
<td>293.0624</td>
</tr>
<tr>
<td>III</td>
<td>4.6040</td>
<td>67.8126</td>
<td>37.0276</td>
<td>0.8537</td>
<td>-</td>
<td>110.2979</td>
</tr>
<tr>
<td>L1+VI</td>
<td>0.3643</td>
<td>27.4295</td>
<td>30.487</td>
<td>5.7175</td>
<td>-</td>
<td>63.9985</td>
</tr>
<tr>
<td>L1</td>
<td>1.3287</td>
<td>1.0311</td>
<td>0.4909</td>
<td>0.8846</td>
<td>0.4804</td>
<td>4.2857</td>
</tr>
<tr>
<td>IV</td>
<td>-</td>
<td>12.4621</td>
<td>20.6286</td>
<td>0.4277</td>
<td>-</td>
<td>33.5086</td>
</tr>
<tr>
<td>L2</td>
<td>-</td>
<td>0.5289</td>
<td>2.8432</td>
<td>4.5345</td>
<td>-</td>
<td>7.9066</td>
</tr>
<tr>
<td>V</td>
<td>-</td>
<td>2.3953</td>
<td>59.1708</td>
<td>14.4679</td>
<td>-</td>
<td>75.9840</td>
</tr>
<tr>
<td>VIA</td>
<td>-</td>
<td>3.0096</td>
<td>14.4681</td>
<td>5.3606</td>
<td>-</td>
<td>22.8373</td>
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</table>
## Natural Gas Composition

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Description</th>
<th>Composition (Mole %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-</td>
<td>Methane</td>
<td>93.093 - 98.713</td>
</tr>
<tr>
<td>2-</td>
<td>Ethane</td>
<td>05.839 - 1.130</td>
</tr>
<tr>
<td>3-</td>
<td>Propane</td>
<td>00.563 - 0.0002</td>
</tr>
<tr>
<td>4-</td>
<td>Isobutane</td>
<td>00.124 - 0.0020</td>
</tr>
<tr>
<td>5-</td>
<td>Neobutane</td>
<td>00.132 - 0.0020</td>
</tr>
<tr>
<td>6-</td>
<td>IsoPentane</td>
<td>00.008 - 0.0001</td>
</tr>
<tr>
<td>7-</td>
<td>Neopentane</td>
<td>00.002 - 0.0002</td>
</tr>
<tr>
<td>8-</td>
<td>Nitrogen</td>
<td>00.239 – 0.1525</td>
</tr>
</tbody>
</table>

**Specific Gravity**
- 0.59370 – 0.56103

**Average GCV in Kcal/SCM**
- 9531.853 – 9088.752

**Average NCV in Kcal/SCM**
- 8599.226

**Pressure**
- 80 Kg/CM2

**Temperature**
- 25°C
## Utility & Offsite Facilities Parameters - Incoming and Outgoing

<table>
<thead>
<tr>
<th>S.L.</th>
<th>Utility Facilities</th>
<th>Required /Generated quantity (Min/Nor/Max)</th>
<th>Unit Of Measurement</th>
<th>Composition %</th>
<th>Pressure at B/L (Kg/cm²g) (Min/Nor/Max/design)</th>
<th>Temperature (Deg C) Min/Nor/Max/design</th>
<th>Line Size (Inch)</th>
<th>Line (MOC) &amp; Rating</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
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<td></td>
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</tbody>
</table>

### INCOMING

<p>| | | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>

### OUTGOING

|      |                    |                                             |                    |               |                                               |                                         |                 |                   |        |
SECTION: VI - 3.0

BIDDER’S SCOPE OF WORK

PLANT: STEAM GENERATION PLANT

PROJECT: INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA)
## CONTENTS

<table>
<thead>
<tr>
<th>Section Number</th>
<th>Description</th>
<th>Sheet Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>GENERAL</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>BIDDER'S SCOPE OF WORK</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>BROAD SCOPE OF WORK/ SERVICES</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>OTHERS REQUIREMENT</td>
<td></td>
</tr>
</tbody>
</table>
1.0 GENERAL

LSTK CONTRACTOR shall supply & install Steam Generation Plant on proposed Coal Gasification based Fertilizer complex, Talcher Fertilizers Ltd. (TFL) at Talcher, Angul District, Odisha (India) as per the requirements and specifications.

1.1 BIDDER’S SCOPE OF WORK

Scope of work of the LSTK Contractor shall include supply of Basic Design and Detailed Engineering, Procurement, Supply, Fabrication, Inspection by Third Party Inspection Agency (TPI) as applicable, Expediting, Route survey for Over Dimensional Consignments (ODCs), Insurance, Transportation of all equipment / materials to work site, Storage, construction and erection of all civil, mechanical, electrical and instrumentation works, insulation, painting as per specification assembly and Installation, obtaining all necessary statutory approvals, Testing, Mechanical Completion, Pre-Commissioning, Commissioning, Sustained Load Test Run, Performance Guarantee Test Run (PGTR), six months supervisory assistance for operation & maintenance including Total Project Management and handing over of the plants and facilities under contractor’s scope of work duly completed on single point responsibility basis.

Bidder scope of supply & service shall be read in conjunction with Section-VI-4.0 & Section-VI-5.3.7 of this Tender.

The Plant shall be installed outdoor and should be suitable for all weather conditions at site.

1.2 BROAD SCOPE OF SUPPLY/ WORK/ SERVICES

The following plants and facilities shall be under the scope of the LSTK Contractor for Steam Generation Plant and Bidder’s scope of work shall include (but not limited to) following in respect of all equipment, works, systems, facilities & services as required for completeness, satisfactory operation and rated outputs of ‘Steam Generation Plant’ on lump sum turnkey (LSTK) and single-point responsibility basis:

a) Coal feeding & handling system
b) Fluxant (if required) feeding & handling system
c) Crushers/ Mill for coal (-) 30 mm to the required size Crushers/ Mill for Fluxant (if required) to make the required size
d) Boilers along with all accessories –3 nos. (2W+1S)
e) Superheating arrangement for HP saturated steam in all 3 nos. Boiler
f) FGD (Flue Gas Desulphurization Unit) & De-NOx unit for SOx & NOx removal (if required) along with necessary unloading and Pumping & Handling facilities for ammonia & other chemicals. LSTK Contractor’s responsibility is to meet Central & State Pollution Control
Board’s norms in all respect along with SOx, NOx & dust emission norms whichever is more stringent

g) Dedicated RCC Flue Gas Stack for each Boiler to meet emission norms of Central and State pollution control boards whichever is more stringent.

h) Fly ash & Bed ash Removal, Handling & Transportation system to overhead bunker & disposal area within TFL B.L.

i) BFW System (Refer Section-VI-4.0)

j) One no. DM water storage tank along with required pumping facilities and interconnecting piping & fittings for catering 4 hours requirement at normal operating condition.

k) Chemical dosing system :- High pressure & Low pressure (as per requirement):
   a) Independent High pressure dosing system for each boiler with 1W+1S pumps configuration with metering tank. Common preparation tank for all three Boilers.
   b) Common Low Pressure dosing system with 1W+1S pumps configuration, preparation tank and metering tank.

l) Oily Water Separator (OWS) inside LSTK Contractor’s B.L.

m) Central Boiler Control room with all accessories such as DCS, Interlock PLC, BMS PLC, SWAS system, Analyzers etc. (Refer Instrument design philosophy Section-VI-5.2 for details)

n) Fire water network system within steam generation plant Battery limit. Fire fighting & safety system for LSTK’s scope of work as per requirement of NFPA, IS, TAC

o) Procedure and arrangement for safe disposal of hazardous solid waste

p) First fill of all catalyst, chemicals & lubricants and requirement during Pre-Commissioning, Commissioning, Sustained Load Test Run and Performance Guarantee Test Run (PGTR).

q) Chemical storage facility for 15 days.

r) Supply of chemicals, lubricants and consumables required for a period of six months from completion of Successful Commissioning.

s) Six month (After Successful Commissioning) supervisory assistance with designated selected manpower defined by owner in section 2.21 of this section

t) Suitable High pressure Instrument Air storage Vessel with compressor & necessary arrangement for supplying instrument air for 15 minutes’ operation or safe shutdown whichever is higher.

u) Emergency Power requirement within LSTK battery limit shall be furnished by LSTK Contractor. DG and Power distribution board for emergency power shall be provided by LSTK Contractor.
v) All Piping Works within SGP Battery Limit (Refer Section-VI-5.3.1 Design Philosophy : Piping for details)
w) Civil & Structural Work (Refer Section-VI-5.4 Design Philosophy : Civil & Structural Works for details)
x) All material handling works within SGP Battery Limit (Refer Section-VI-5.3.4 Design Philosophy for Coal & Ash Handling.
y) All rotating equipment/ HVAC/ EOT Crain works within SGP Battery Limit (Refer Section-VI-5.3.3/ 5.3.6/ 5.3.8 respectively)
z) All Instrument & control work (Refer Section-VI-5.2 Design Philosophy for Instrument & Control.

aa) Dismantling of temporary construction facilities and cleaning the site by removal & disposal of debris etc. after project completion.
bb) LSTK Contractor shall design the Steam Generation Plant to accommodate within the available area marked in plot plan for Talcher Fertilizer Complex.
cc) CCOE permission to be taken by LSTK contractor for any petroleum product being handled by him.

dd) Continuous blow-down valve shall have arrangement for locking at any position.

ee) All safety valve and vent valves shall be complete with silencers. The steam escape piping shall be provided to discharge steam at a safe height above the height operating point/ floor.

The followings shall also be under the scope of the LSTK Contractor for Steam Generation Plant:

a. Design, Basic & Detailed engineering, preparation of PFDs, P&IDs, Heat & Mass balance, Cause & Effect Diagram, interlock description along with Control philosophy
b. Compliance of all statutory requirements during complete project execution period, PGTR.
c. Preparation of drawings and Documents with necessary software and hardware including submission of as built drawings.
d. Getting the drawings approved, making prints available well before those are actually required by manufacturer, inspector, erector, constructor, site engineer
e. Procurement and/or Manufacture and/or Fabrication,
f. Quality assurance & Quality Control
g. Inspection, Testing, checking, Expediting at Manufacturer's works including inspection by Owner/ Consultant/ Third party/ Statutory Authorities including IBR.
h. Supply, Packing, loading, un-loading, Transportation of all equipment & material to site including customs clearance and port charges, port handling & handling at work site.
i. Route survey for Over Dimensional Consignments (ODCs)
j. Storage, preservation and conservation at site as per manufacturer’s recommendation until erection,

k. Security, Watch & ward till handing over

l. Insurance during transit, storage, erection and commissioning

m. Mechanical completion, Construction and Erection of all civil, structural, mechanical, electrical and Instrumentation items/ works, assembly, installation including loading of materials at contractors warehouse, transportation of materials to contractor’s works/erection site.

n. Testing/ checking at site by Owner/ Consultant/ Statutory Authorities including IBR and obtaining all necessary statutory approvals from concerned government authorities as applicable

o. Obtaining necessary statutory clearances pertaining to execution of Steam package.

p. Supply of spares shall be as per Section-VI-10.0 of NIT.

q. Supply of spares required for 2 years normal operation & maintenance of installation

r. Supply of all equipment, machinery, tools etc required for proper & safe erection/ construction work.

s. Supply of all special tools & tackles

t. Supply and installation of instruments for minor repair & testing work.

u. Training of Owner’s personnel as per Section-VI-12.0 Handing over of ‘Steam Generation Plant and associated utilities’ with all final ‘As-built drawings/ documents’ and operating manual. Drawings, documents & operating manual of bought out items. Test certificates and statutory approvals.

v. Preparation of Network and schedules in latest version of Primavera. Project Planning, Scheduling & monitoring, progress Monitoring and Reporting, Total project management.

w. Co-ordination with all agencies concerned with implementation of the project.


y. All items and equipment though not specifically mentioned in the specification, but needed to complete the system to meet the intent of the specification shall be deemed to be included in the scope of the bidder.

z. Bidder shall note that any work and/ or services mentioned in other sections of tender document and not mentioned in this section or mentioned in this section and not mentioned in other sections shall be considered as if mentioned in both.

aa. All supervision personnel, skilled/ unskilled labour for completing the job in all respect as per provision of the contract.

bb. Custody flow meters of various raw materials & utilities to be provided for permanent measuring arrangements the guaranteed parameters inside their B.L.
1.3 The following Offsite & Utility plants shall be excluded from the scope of LSTK contractor of Steam Generation Plant:
   I. Coal handling and Transportation from Pithead to LSTK B/L.
   II. Coal/ Fluxant (if required) of (-) 30mm size Storage for 15 days.
   III. Instrument & Plant air system
   IV. Inert Gas Generation System
   V. Cooling tower with all associated facilities

1.4 Following raw material & utilities shall be made available to the LSTK contractor at one point Steam Generation Plant Battery Limit after mechanical completion of the unit.
   a) Coal and Fluxant (if required)
   b) Treated water
   c) DM water
   d) Fire water
   e) Instrument Air
   f) Plant Air
   g) Nitrogen
   h) Cooling water
   i) Drinking water/ Potable water

2.0 OTHER REQUIREMENTS

2.1 Tie-up/ hook-up with designated tie-up points for hooking up to other systems executed by other agencies. Perform construction management and supervision of all equipments, material and works.

2.2 Provide and perform comprehensive quality assurance, quality control and inspection of all equipments, materials works - both in manufacturing shop and at work site.

2.3 Provide all manpower, materials, consumables, construction equipment / machines, tools, instruments, storage, fabrication, facility and all other services and inputs etc. necessary to perform the work and complete the plant.

2.4 Comply with all Central, State & Local Govt. regulations, laws and requirements applicable to the work and seek & obtain approvals/ clearances from such statutory bodies/ agencies, as required. Scope of Talcher Fertilizers Limited in this regard will be only to provide authorization in favor of LSTK CONTRACTOR for which all the necessary paper work will be done by LSTK CONTRACTOR.

2.5 Provide necessary temporary construction facilities like fabrication, storage, illumination etc. and removal of temporary arrangement to make the space reusable.

2.6 Comply with all safety practices for and during work as per applicable standards.
2.7 Strictly comply with applicable codes and standards of Engineering, Fabrication, Inspection, Construction etc.

2.8 Arrange services of Manufacturer's installation/ commissioning Engineer(s) at Site during Mechanical Completion, Pre-commissioning, Commissioning and GTR of the entire major equipment and systems.

2.9 Provide all the temporary connections/ supplies required for testing/ pre-commissioning activities and also to provide all instrument metering systems required for measurements of various parameters/ testing during test runs.

2.10 Provide spare parts including all consumables for start-up, pre-commissioning, commissioning, Sustain Load Test Run, PGTR of plants. All such spares are to be available at site prior to commissioning and start up of the plant including various test runs.

2.11 Perform testing, flushing, cleaning and pre-commissioning, start-up/ commissioning. Sustained load run, PGTR.

2.12 Submission of final drawings and documents shall be as per Section No 9.0 (Drawings and Documents) of Part-II Technical.

2.13 Project Management and planning, scheduling and monitoring/ comprehensive reporting services, periodic reviews, meeting notes with Talcher Fertilizers Limited / PMC.

2.14 The scope of work as described above shall be supplementary to the scope of work mentioned under various parts of Tender Document. In case of any contradiction between the two, the stipulations mentioned under various disciplines shall be governing. In this regard, Owner’s interpretation shall be final and binding to LSTK CONTRACTOR.

2.15 Transportation of all the materials supplied by Owner, if any, from TFL’s store to LSTK CONTRACTOR's Store/ work site including loading/ unloading.

2.16 Total painting including special paints, color coding, insulations, refractory, CS / S.S. name plates etc. as per applicable standards.

2.17 Any other work not specifically mentioned above but required for completeness of the plant shall be undertaken by the LSTK Contractor without any additional cost implication to the owner.

2.18 LSTK CONTRACTOR shall perform the HAZOP, HAZAN, SIL Study etc. and implement the recommendations of HAZOP, HAZAN, SIL Study etc. without any additional cost / time schedule implication to Owner.

2.19 LSTK CONTRACTOR shall adhere to Design Control exactly as per provisions of latest ISO 9001. LSTK CONTRACTOR shall submit required records as evidence for
review by Owner/ PMC as and when required, and shall carry out changes based on Owner/ PMC review.

2.20 LSTK contractor shall supply the lubricants, chemicals and other consumables in the LSTK price for the six months after Guarantee Test Run in addition to the Pre-commissioning/ Commissioning/ Sustained Load Test Run and PGTR spares and consumables. Quantity of lubricant, chemicals & consumables shall be based on 100% plant load operation. For subsequent two year requirement, LSTK contractor to provide the list along with price of recommended spares and consumables. However, price is not to be included in the lump sum price.

2.21 Owner desires six months (after Successful Commissioning) Supervisory assistance for Operation & Maintenance with designated selected manpower defined by Owner in below table. LSTK Contractors shall indicate the man-day/ man-month rate in Schedule of Rate.

Manpower required for Supervisory assistance for O&M:-

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Discipline</th>
<th>Designation</th>
<th>No. of personnel</th>
<th>Qualification</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Operation</td>
<td>Supervisor</td>
<td>01</td>
<td>B.E./ B.Tech/ Diploma (Note-1)</td>
<td>Min. 10 year</td>
</tr>
<tr>
<td>2.</td>
<td>Electrical</td>
<td>Supervisor</td>
<td>01</td>
<td>B.E./ B.Tech/ Diploma</td>
<td>Min. 10 year</td>
</tr>
<tr>
<td>3.</td>
<td>Instrument</td>
<td>Supervisor</td>
<td>01</td>
<td>B.E./ B.Tech/ Diploma (Note-2)</td>
<td>Min. 10 year</td>
</tr>
<tr>
<td>4.</td>
<td>Mechanical</td>
<td>Supervisor</td>
<td>01</td>
<td>B.E./ B.Tech/ Diploma</td>
<td>Min. 10 year</td>
</tr>
</tbody>
</table>

Note-1 The Manpower mentioned in Sr.-1 must have the certificate in Boiler Operation Engineer (BOE).

Note-2 Instrument discipline personal must have the experience of DCS, field & other instruments.

2.22 Supervisory assistance.

2.23 LSTK contractor shall arrange complete manpower mutually agreed by Owner & LSTK Contractor for Pre-Commissioning, Commissioning, Sustained Load Test Run, PGTR, Operation & Maintenance and Supervisory Assistance.

2.24 Lab & lab equipment is not in LSTK scope, List of equipment & apparatus shall be furnished along with BID by LSTK contractor required for testing during the Pre commissioning, commissioning, PGTR & subsequent Operation.

2.25 All geo –technical requirement including geo-technical investigation.

2.26 All civil works and supplies such as painting, provision of the fire water network & system around the boiler as per TAC,IS, NFPA and connection of blow down and oily waste with storm sewers and OWS respectively near the plant area as per general civil specs.

2.27 During erection/ construction LSTK contractor shall ensure that construction of other LSTK contractor should not hamper.
2.28 Feed control station for start-up and normal operation.

2.29 Each Boiler unit shall have its own independent CBD & IBD systems

2.30 Following motor operated valve with provision of manual operation shall be provided as minimum:
   
   a. Main steam stop valve and its bypass.
   b. Start-up vents valve and its isolation valve.
   c. Continuous blow down valve and isolation valve.
   d. Emergency drain valve and its isolation valve.
   e. 1st isolation for each feed control valve.
   f. 1st isolation valve of each PRDS.
SECTION: VI - 4.0

PROCESS DESIGN BASIS

PLANT: STEAM GENERATION PLANT

PROJECT: INTEGRATED COAL BASED FERTILISER COMPLEX AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA)
## CONTENTS

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<th>Sheet Number</th>
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</tbody>
</table>
1.0 GENERAL
This document (Design basis) covers the requirements for design of Coal fired Steam Generation Plant to be constructed by Contractor on LSTK basis.

2.0 REQUIREMENT PERTAINING TO STEAM GENERATION PLANT
Steam Generation Plant is the source of steam required for the operation of Coal Gasification Plant, Ammonia & Urea Plant, Offsite plants of entire fertilizer complex. Steam generated at required battery limit condition in Steam Generation Plant shall meet the requirement of the entire fertilizer complex. LSTK CONTRACTOR is required to construct the Steam Generation Plant to meet export steam requirement at a required rate, specified pressure and temperature conditions to the Fertilizer Complex steam network continuously during the on-stream days (330 days in a year) of the Complex.

Steam Generation Plant shall be complete in all respect and any item or feature not covered in this specification but essential for safe, reliable & efficient operation & maintenance shall be included by LSTK Contractor.

The Steam Generation Plant shall be designed to meet the following requirements of export Steam at B.L.

STEAM REQUIREMENT

H.P. Superheated Steam Generation
Continuous Normal requirement: 564 MT/hr (100% Plant Load)
Superheating of H.P. Saturated Steam
A separate stream of H.P. saturated steam of 74 Mt/hr (at Normal Flow) from Ammonia-Urea Plant shall be superheated in Steam Generation Plant & will meet the parameters of H.P. superheated steam to be exported to the steam header at the B.L. H.P. saturated Steam quantity may vary from 0 to 82 Mt/hr based on AMMONIA-Urea running status. LSTK contractor to design the super-heater coil & boiler control accordingly.

Refer Section-VI-2.0 for quality parameter of steam.

3. DESIGN BASIS AND CAPACITY

3.1 Steam Generation Plant
There shall be three (3) boilers (2W+1S) of identical capacity for generation of superheated HP steam of 564 Mt/hr which will be exported at B.L.

A stream of Saturated HP steam from Ammonia Plant will be superheated in the operating Boilers. Same shall be made available at LSTK’s B.L. by Owner. Each Boiler shall be capable to superheat additional import saturated steam of 41 Mt/hr from Ammonia Plant. Separate fired arrangement for superheating the H.P. saturated steam shall not be considered.
Net output of H.P. superheated steam shall be supplied through a single header at LSTK Contractor's B.L.

Type of boiler shall be selected by the LSTK Contractor as per specified conditions of steam generation in Section-VI-2.0. Type of boiler may be either “circulating fluidized bed Combustion type (CFBC)” or “conventional pulverized coal type (PC)”. LSTK Contractor to meet the latest pollution norms and guideline as applicable. LSTK Contractor to note that evaluation criteria will be based on both capital cost & operating cost considering plant life of 25 years.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Description</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Net Steam export to owner</td>
<td>MT/hr</td>
<td>638 (564+74) (Note-1)</td>
</tr>
<tr>
<td>2.</td>
<td>Internal Consumption inside LSTK B.L if any</td>
<td>MT/hr</td>
<td>LSTK to specify</td>
</tr>
<tr>
<td>3.</td>
<td>Total Steam Generation (Sum of sr. no 1 &amp; 2)</td>
<td>MT/hr</td>
<td>LSTK to specify</td>
</tr>
<tr>
<td>4.</td>
<td>Steam Generators configuration (Boiler)</td>
<td>Nos.</td>
<td>2W+1S</td>
</tr>
<tr>
<td>5.</td>
<td>Capacity of each Steam generator (Boiler)</td>
<td>MT/hr</td>
<td>LSTK to specify</td>
</tr>
</tbody>
</table>

**Note-1:** - Net quantity of HP superheated steam export includes the amount of HP saturated steam at the rate of 74MT/hr (after superheating, within the battery limit of steam generation plant). The steam will be made available for superheating at the B/L of LSTK contractor’s facility at the specified condition mentioned in the Section-VI-2.0.

**Note-2:**- A stream of LP steam of 10 MT/hr shall be made available by LSTK Contractor at their B.L. for owner use. The specification of steam has been mention in section 2.0 Part-II Technical.

The best machine performances are achieved at specified steam super heat temperature. It is preferred to have a positive control on superheat temperature i.e. the heat transfer surfaces provided for steam superheat in process and convection zone super heaters shall have adequate area to achieve temperature of 15°C above specified superheat temperature and the final superheat temperature control shall be by attemperation.

De-superheating function for various steam headers shall be done through proper devices such as steam conditioning valves to achieve minimum water carry over and wide range operations with quick response type to prevent depressurization of the header.

**3.2 Boiler Feed Water(BFW) SYSTEM**

**DM water**

Make-up DM water shall be made available at LSTK’s B/L by Owner. LSTK Contractor shall provide the DM water storage tank along with pumping (with standby train) & all associated facilities within their B.L. for 4 hours requirement at normal operating condition of Boilers.
De-Aerator

Common De-aerator for three boilers shall be considered for Steam Generation Plant. De-aerating capacity of De-aerator shall be equal to gross MCR steam generation capacity of all 3 nos. Boilers.

The de-aerator shall be of spray-cum-tray type with counter current flow of steam and water. The de-aerator and the storage tank shall be complete with all the fittings and mountings like vents, controlled vent, drains, gauge glasses, pressure indicators, relief valve, steam and water inlet and outlet nozzles, overflow nozzle etc.

The dissolved oxygen content in feed water measured at de-aerator outlet shall not exceed 0.005 mg/litre at all loads from no load to full load condition with normal pressure and overpressure with incoming DM water presumed to be saturated with oxygen (without any chemical dosing).

De-aerator storage tank capacity (Two running boiler) shall be designed for 30 minute of feed water flow at BMCR (Boiler Maximum capacity rating) between normal and low low water level. The free CO2 content of the water shall be ‘Zero’ ppm.

The de-aerator water storage tank shall be provided with two drains. One drain shall be at the bottom most point which shall be connected to the over flow drain to the blow down tank. The other drain shall protrude inside the tank to 25 to 40 mm and it shall be connected to the DM water storage tank. This drain will be used only when the de-aerator is taken up for maintenance.

De-aerator Steam may be arranged from two sources: 1) Boiler Blow Down Drum; 2) Balance LP/MP Steam available from turbine drives inside steam generation plant B.L.

An online O2 analyser at outlet of De-aerator shall be provided for continuous monitoring of required parameters of boiler feed water.

Level transmitter with 2oo3 voting logic shall be provided.

BFW Pump

Each Boiler shall have dedicated 1W+1S BFW Pump configuration.

Boiler feed water pumps shall be capable of meeting the peak generating capacity of the boiler and 2% blow down requirements of the boiler under peak generation. The peak generation capability of the boiler shall be the MCR capacity of the boiler.

Drive of BFW pumps shall meet the stipulations of IBR regulation in force. Minimum circulation line shall be provided for each pump and shall be terminated at De-aerator. Motor drives shall have VFD with bypass arrangement. Suction strainer of BFW pump with remote & local differential pressure indication shall be included for each pump. Auto start of BFW shall be provided.

Boiler feed water treatment

Boiler feed water treatment shall be All Volatile Treatment. Refer Section-VI-3.0
The boiler shall be provided with a tri-sodium phosphate based High pressure (HP) dosing system and oxygen scavenging chemical Low Pressure (LP) dosing system. The HP dosing system shall add the chemical to the boiler water to increase the boiler water pH as per the coordinated pH Vs Phosphate curve. The LP dosing is done to the feed water preferably at the outlet of the de-aerator to scavenge the last traces of oxygen and to increase the feed water pH.

HP dosing pump and other system sizing shall be with One percent (1%) concentration of Tri-sodium-Phosphate with residual phosphate level of 7 ppm in the boiler water and also considering 2% blow down on the peak steam flow. The tank usable volume (the volume between bottom of the overflow nozzle and top of the outlet nozzle) shall be for 24 hours. However, the minimum usable capacity shall be 500 litres. On the quantity of dosing chemical calculated based on the above, 25% margin shall be added to arrive at the rated flow of the pump.

The LP dosing system sizing shall be with 0.1% concentration of oxygen scavenging chemical to remove the residual oxygen in the feed water. In addition, there should be residual oxygen scavenging chemical level of 0.02 PPM in the feed water. The tank usable volume (the volume between bottom of the overflow nozzle and top of the outlet nozzle) shall be for 24 hours. However, the minimum usable capacity shall be 500 litres. On the quantity of dosing chemical calculated based on the above, 25% margin shall be added to arrive at the rated flow of the pump.

3.3 Steam Pressure Reducing and De-superheating Station (PRDS)
Contractor shall provide complete steam pressure reducing and de superheating station (PRDS) system to meet the steam requirement during unit normal operation, intermittent steam requirement of units and station and auxiliary steam equipment for the start-up of the units. Each unit shall be provide with a high capacity pressure reducing and de superheating station (HCPRDS) taking tap off from Main Stream (MS) or intermediate stage of super-heaters (as per bidder’s standard practice).

The steam systems of all units shall be suitably interconnected, so as to enable start-up of unit by taking auxiliary steam from any of the other running unit of the station.

High Capacity PRDS (HCPRDS)
The bidder may offer combined pressure reducing cum de superheating valve or a pressure reducing valve with separate de super-heater.

i. Combined High Capacity PRDS
   a) One number electro pneumatically operated combined pressure reducing cum de superheating valve rated for full duty.
   b) One number motorized isolation valve with integral bypass at the upstream of the pressure reducing cum de superheating valve.
   c) One number non-return valve and one number motorized isolating valve at the downstream of pressure reducing cum de superheating valve.
d) Spray control station comprising of one number each of pressure and temperature control valve, electro pneumatically operated, on the de superheating spray water line along with an identical 100% capacity bypass arrangement.

e) One number motorized isolation valve at the inlet of each of electro pneumatic control valve on the de superheating spray water line.

f) One number motorized isolation valve at the downstream of each of electro pneumatic control valve on the de superheating spray water line. One number of non-return valve on the common spray water line.

ii. HCPRDS with separate de super-heater

a) One number /electro pneumatically operated pressure reducing valve with separate de-super heater rated for full duty.

b) One number motorized isolation valve with integral bypass at the upstream of the pressure-reducing valve.

c) One number non-return valve and one number motorized isolating valve at the downstream of pressure reducing valve.

d) One number of temperature control valve electro hydraulically/electro pneumatically operated on the de-superheating spray water line along with an identical 100% capacity bypass arrangement.

e) One number motorized isolation valve at the inlet of each of electro hydraulic/ electro-pneumatic control valve on the de-superheating spray water line.

f) One number motorized isolation valve at the downstream of each of electro hydraulic/ electro-pneumatic control valve on the de-superheating spray water line. One number of non-return valve on the common spray water line.

3.4 ID & FD Fan

ID & FD Fan for each boiler shall have the configuration of 1W+1S. ID & FD fan shall be Electric motor drive or Steam turbine drive depending upon. However, electric motor drive is preferred. If Steam Turbine drive is selected for Working ID & FD fan then standby ID & FD fan shall have the electric motor drive. Motor drives shall have VFD with bypass arrangement. Capacity of each fan shall be 120% of normal conditions.

In addition, the fans shall also be provided with inlet damper operation in case of failure of VFD. The damper shall be manually controlled from the control room, through pneumatically operated power cylinder incorporating suitable linkages. The fan shall also have solenoid operated damper at fan outlet. IGV / damper operating links / drives should be mounted outside to the extent possible to avoid settlement of dust on links. The fan speed shall not exceed 1000 RPM. The impeller shall be hard faced to avoid erosion of the impeller blades.

3.5 Primary Air Fan (1W+1S) (In Case of CFBC type Boiler)
The Primary Air fan shall be variable speed, horizontal, radial, backward curved and electric motor driven. Primarily the fan control shall be with Variable Frequency Drive (VFD). However, the fans shall also be provided with inlet guide vanes operation in case of any problem in the VFD and the inlet guide vanes shall be controlled through power cylinder. The inlet guide vanes opening shall be manually operated from the control room through pneumatically operated power cylinder incorporating suitable linkages. The fan shall also have solenoid operated damper at fan outlet. IGV / damper operating links/drives should be mounted outside to the extent possible to avoid settlement of dust on links. The fan shall be direct driven with the maximum speed not exceeding 1440 RPM.

3.6 Secondary Air Fan (1W+1S) (In case of CFBC type Boiler)
The Secondary air fan shall be variable speed, horizontal, radial, backward curved and electric motor driven. Primarily the fan control shall be with the variable frequency drive (VFD). In addition, the fans shall also be provided with inlet guide vane operation in case of any problem in the VFD. The inlet guide vanes shall be manually operated from the control room through pneumatically operated power cylinder incorporating suitable linkages. The fan shall also have solenoid operated damper at fan outlet. IGV / damper operating links/drives should be mounted outside to the extent possible to avoid settlement of dust on links. The fan speed shall not exceed 1440 RPM.

3.7 Seal Air Fan/ Scanner Fan
As per equipment requirement, LSTK Contractor to provide the seal airFan/ Scanner Fan.

3.8 LSTK Contractor to consider flame detection mechanism suitable to the Boiler technology.

3.9 Electrostatic Precipitator - CFBC Steam generator
The electrostatic Precipitator shall be sized for the fuel firing conditions as specified in Section-VI-2.0. For the above fuel, the SUPPLIER’s design basis for sizing ESP can be used and the SUPPLIER shall indicate the design basis in the offer.

<table>
<thead>
<tr>
<th>Dust inlet concentration</th>
<th>Based on flue gas ash to be obtained from Coal containing 43.5% of ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESP dust outlet concentration</td>
<td>&lt; 30 mg/Nm³</td>
</tr>
<tr>
<td>Flue gas design temperature</td>
<td>200°C</td>
</tr>
<tr>
<td>Flue gas operating temperature</td>
<td>150 to 170°C (approx.)</td>
</tr>
<tr>
<td>Pressure drop in the ESP</td>
<td>25 mm WC</td>
</tr>
</tbody>
</table>

3.10 Bottom Ash Air Cooler (If required)
Air cooled bottom ash cooler consider for bed ash cooling with required bed ash cooler outlet gate and bypass chute for the bed ash coolers. Bed ash cooler design capacity shall be selected suitably.

3.11 Sample Coolers
Individual sample cooler for super heated steam, Boiler feed water, Boiler Blow down water shall be supplied and complying ASME PTC 19.11 standard. Suitable draining provision shall be included.

### 3.12 On Stream Factor

Plant design and engineering are to be carried out for achieving a high degree of operational reliability. The plants are to be designed with high on-stream factor with minimum operating cycle of 2 years (including statutory requirement) between turn around.

### 3.13 Turn down Ratio

Minimum turndown ratio shall be 40% for each Boiler capacity without sacrificing product steam quality & considering safety of equipment and operating personal.

### 3.14 Overall Specific Energy Consumption

LSTK contractor shall design plants and utilities under their scope of work to achieve minimum overall specific energy consumption per A) Gcal/ MT of Superheated HP steam and B) GCal/ MT for superheating HP saturated steam (Parameter as given in Section-2.0 part II Technical). LSTK contractor shall indicate specific consumption of raw materials and utilities for plant B.L.

### 3.15 Stack

Individual Boiler shall have the dedicated RCC stack for flue gas venting. Flue gas stack shall be provided with all necessary instruments for online measurement of pollutants as per SPCB/ CPCB. Heat Recovery from the flue gas should be limited such that the flue gas temperature at the exit of economizer is above acid dew point.

### 3.16 Drives

The selection of drives shall be preferred as follows. However, LSTK Contractor may adopt any other configuration as per good engineering practice for the sake of energy optimisation with proper justification. LSTK Contractor to note that Max. Power for SGP Package shall not exceed 8MWhr/Hr. Accordingly, Contractor shall design the LSTK package accordingly.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Turbines/Pump</th>
<th>Type of Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Boiler feed water pumps</td>
<td>Electric Motor Driven (VFD with bypass) &amp; Steam driven Considering IBR requirement</td>
</tr>
<tr>
<td>2.</td>
<td>Operating Lube Oil pumps</td>
<td>Electric Motor</td>
</tr>
<tr>
<td>3.</td>
<td>Condensate Pump</td>
<td>All pumps shall be Electric Motor Driven.</td>
</tr>
<tr>
<td>4.</td>
<td>De-aerator Feed Pump</td>
<td>All pumps shall be Electric Motor Driven.</td>
</tr>
<tr>
<td>5.</td>
<td>ID Fan &amp; FD Fan</td>
<td>Motor Driven with VFD or Steam Turbine driven</td>
</tr>
<tr>
<td>6.</td>
<td>Air compressor for fluidization (If required)</td>
<td>Motor Driven</td>
</tr>
</tbody>
</table>

### 3.17 Selection of Material of Construction
In general, material selection for all the sections of Steam Generation Plant shall be as per good Engineering Practice in order to avoid corrosion problem. Minimum requirements of materials of construction for some major equipment are as follows. However, LSTK Contractor may provide any superior material than as specified if required by the process.

3.18 Plant Equipment Metallurgy

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Service</th>
<th>Material of Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coal Fired Boiler</td>
<td>As per Licensor recommendation</td>
</tr>
<tr>
<td>2</td>
<td>Boiler Drum</td>
<td>CS (Boiler Grade)</td>
</tr>
<tr>
<td>3</td>
<td>Superheating Coils</td>
<td>2.25 Cr-1Mo or Superior</td>
</tr>
<tr>
<td>4</td>
<td>De-aerator</td>
<td>Storage vessel = CS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stripping section = SS</td>
</tr>
<tr>
<td>5</td>
<td>FGD Absorber lining (if required)</td>
<td>Haste alloy C-276 or equivalent</td>
</tr>
</tbody>
</table>

# BIDDER to furnish reference plant with suggested MOC in operation.

3.19 Critical Piping

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Service</th>
<th>Material of Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>DM water</td>
<td>SS 304</td>
</tr>
<tr>
<td>2.</td>
<td>Instrument air</td>
<td>SS 304</td>
</tr>
<tr>
<td>3.</td>
<td>Lube oil and seal oil</td>
<td>SS 304</td>
</tr>
<tr>
<td>4.</td>
<td>Phosphate/ Hydrazine / Morpholine</td>
<td>SS 304, SS-316</td>
</tr>
<tr>
<td>5.</td>
<td>High pressure steam for temp above 460°C</td>
<td>2.25 Cr.1Mo</td>
</tr>
<tr>
<td>6.</td>
<td>High pressure steam for temp below 460°C</td>
<td>1.25Cr 0.5Mo</td>
</tr>
<tr>
<td>7.</td>
<td>Medium &amp; Low pressure steam tem &lt; 425°C</td>
<td>A106 Gr. B Seamless</td>
</tr>
</tbody>
</table>

3.20 Effluent Treatment & Pollution Level

Gaseous emissions are expected from Vent Stacks of Boiler Flue Gas. Pollutants viz. SOx, NOx, CO, Un-burnt fuel, SPM etc. Liquid effluents like Boiler Blow Down, Ash handling water, Oily water etc also will be generated from Steam Generation Plant area. LSTK Bidder shall consider adequate measure to maintain the pollution level below norms stipulated by CPCB/Odisha Pollution Control Board. Bidder to consider online data transmission provisioning to Pollution Control Board as latest CPCB/SPCB norms.

Liquid Effluents

The ETP facility *(Owner's scope)* shall treat all effluents, continuous, intermittent or emergency discharges from all process and utility units. LSTK Contractor shall design the ISBL plants such that most of the effluents are recycled back, resulting in zero effluent discharge. LSTK Contractor shall indicate quantity and concentration of the significant components of liquid effluents generated during normal plant operation, plant start up, plant shut down and during any emergencies.
There will be underground drainage system to collect the floor washing etc. to carry effluent to ETP. The condition of effluent at the battery limit of Steam Generation Plant is as indicated below:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oil &amp; Grease</td>
<td>10 mg/l (Max.)</td>
</tr>
<tr>
<td>2</td>
<td>pH</td>
<td>6-9</td>
</tr>
<tr>
<td>3</td>
<td>Cyanide as N</td>
<td>Nil</td>
</tr>
<tr>
<td>4</td>
<td>Suspended Solids</td>
<td>Max. 100 mg/l</td>
</tr>
</tbody>
</table>

Gaseous Emission

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Source</th>
<th>Suspended Particulate Matter (mg/Nm³)</th>
<th>SOx (mg/Nm³)</th>
<th>NOx (mg/Nm³)</th>
<th>Hg (mg/Nm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Boiler Stack</td>
<td>≤ 30</td>
<td>100</td>
<td>100</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Design of the gaseous emission from various points of the plant shall be based on following considerations:

a) Flue gas vent stack shall have online Analyser to monitor gaseous emission for SPM₁₀, SPM₂.₅, SOₓ, NOₓ.

b) O₂ analyzer for measuring excess O₂ in flue gas at economizer outlet shall be provided.

c) Flue gas stacks height shall be as per norms published in Gazette of India No.-435 dated 29 June 2018:

\[ H = 6.902(QX0.277)^{0.555} \]

Q = Emission rate of SO₂ in kg/hr

H = Physical stack height in meter

Or Minimum 100M.

d) ESP (N-1) per boiler system shall be installed to meet the emission norms.

e) LSTK Contractor shall provide Sampling port of adequate size & at height as defined by CPCB/ Odisha Pollution Control Board. There should be platform of adequate size with step type ladder to approach up to the sampling port.

f) The dust content in the exhaust air shall not exceed more than 50 mg/Nm³.

g) FGD (Flue Gas Desulphurization) & NOx abatement units shall be provided, if required. During PGTR, Required Liquid/ vapour Ammonia shall be arranged by LSTK Contractor. Necessary unloading and Pumping & Handling system shall be provided by LSTK Contractor.

The ground level concentration of the following in the atmospheric air of Plant area shall not exceed the limits given below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM₁₀</td>
<td>100 µg/m³</td>
</tr>
</tbody>
</table>
**Noise Limitation**

Noise nuisance from machinery is normally specified as sound pressure level which for standard design shall not exceed, in work areas, 85 dB (a) at 1m distance from each source. Maximum allowable noise limit shall not exceed 120 dB for emergency conditions, such as safety/relief valve blow off.

Following boundary level noise limits may be adhered to:
- Day time: 75 dB (A)
- Night time: 70 dB (A)

**Note:** According to Noise pollution (Regulation & Control) Rules 2000 for Industrial Area, the day time shall mean from 6.00 am to 10.00 pm and night time shall mean from 10.00 pm to 6:00 am.

### 4.0 SITE CONDITIONS

The design criteria for Steam Generation Plant, which are under the scope of the LSTK Contractor, shall be as per following site conditions:

#### 4.1 Wind

Wind Load Design: as defined in IS: 875 Part 3

Prevailing Wind Direction : Refer Section-5.5 Civil Design Philosophy

#### 4.2 Air Temperature

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Temperature, °C</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry bulb (Summer)</td>
<td>46.3</td>
<td></td>
</tr>
<tr>
<td>Dry bulb (Winter)</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Average Temperature</td>
<td>31.9</td>
<td></td>
</tr>
<tr>
<td>wet bulb</td>
<td>29.0</td>
<td></td>
</tr>
<tr>
<td>Max for Mechanical / Civil / Structural</td>
<td>35.0</td>
<td></td>
</tr>
<tr>
<td>Minimum for winterization (Average)</td>
<td>18.7</td>
<td></td>
</tr>
</tbody>
</table>

#### 4.3 Relative Humidity

<table>
<thead>
<tr>
<th>Relative Humidity</th>
<th>RH%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Humidity</td>
<td>100</td>
</tr>
</tbody>
</table>

#### 4.4 Rainfall

<table>
<thead>
<tr>
<th>Rainfall</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual (Average)</td>
<td>Refer Section-5.5 Civil Design Philosophy</td>
</tr>
<tr>
<td>Design rainfall (per hour)</td>
<td>Refer Section-5.5 Civil Design Philosophy</td>
</tr>
</tbody>
</table>
4.5 Barometric Pressure

<table>
<thead>
<tr>
<th>Barometric Pressure</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>1008 mbar</td>
</tr>
</tbody>
</table>

4.6 Seismic Design Code

Refer Section-5.5 (Design Philosophy – Civil & Structural Works) Part II-Technical.

4.7 Plant Elevation

The final plant elevation shall be established in consultation with owner / consultant based on overall project requirement.
SECTION: VI – 5.1

DESIGN PHILOSOPHY-PROCESS

PLANT: STEAM GENERATION PLANT

PROJECT: INTEGRATED COAL BASED FERTILISER COMPLEX AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA)
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<th>Sheet Number</th>
</tr>
</thead>
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</tr>
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<td>4</td>
</tr>
<tr>
<td>3.0</td>
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<td>5</td>
</tr>
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<td>5</td>
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<td>5.0</td>
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<td>5</td>
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</tr>
<tr>
<td>8.0</td>
<td>Pumps</td>
<td>6</td>
</tr>
<tr>
<td>9.0</td>
<td>Compressors</td>
<td>7</td>
</tr>
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<td>7</td>
</tr>
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<td>7</td>
</tr>
<tr>
<td>12.0</td>
<td>Fouling Factors</td>
<td>8</td>
</tr>
</tbody>
</table>
1. GENERAL

The plants shall be designed to operate safely and satisfactorily at a capacity of 40 to 100% of Design Capacity. Equipment and machinery shall be provided so that the plants can operate for at least two years without major overhaul or inspection. All design shall confirm with the latest edition of the applicable sections of ASME, ASTM, IEEE, NFC, TEMA, AISI, NEMA, AISC, ACI, OSHA, UBE and other governing codes or standard practices.

In addition, the following state/local Codes/laws shall supplement:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>Pressure Vessels/Formed ends</td>
<td>ASME, Section VIII, DIV.I / Indian Standard IS 4049.</td>
</tr>
<tr>
<td>b)</td>
<td>Boilers</td>
<td>Indian Boiler Regulations Act (IBR)</td>
</tr>
<tr>
<td>c)</td>
<td>Buildings &amp; Structural</td>
<td>Relevant Indian Standard (BIS)</td>
</tr>
<tr>
<td>d)</td>
<td>Electricity</td>
<td>Indian Electricity Rules</td>
</tr>
<tr>
<td>e)</td>
<td>Sanitary</td>
<td>Relevant Indian Standard (BIS)</td>
</tr>
<tr>
<td>f)</td>
<td>Safety</td>
<td>a) Manual of Chief Inspector of Explosives, Govt. of India.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) NFPA</td>
</tr>
<tr>
<td>g)</td>
<td>Water Pollution</td>
<td>Relevant Indian Standard (BIS) / Central Pollution Control Board/ Orissa State Pollution Control Board limits norms set by Ministry of Environment &amp; Forest, MINAS</td>
</tr>
</tbody>
</table>

1.1 System of Measurements

The system of measurement shall be Metric as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Preferred Units</th>
<th>Alternative Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Pressure - absolute</td>
<td>kg/cm² abs</td>
<td></td>
</tr>
<tr>
<td>Pressure - gauge</td>
<td>kg/cm² g</td>
<td>kg/hr</td>
</tr>
<tr>
<td>Flow (liquid)</td>
<td>m³/hr</td>
<td>kg/hr</td>
</tr>
<tr>
<td>Flow (gas)</td>
<td>Nm³/hr</td>
<td>kg/hr</td>
</tr>
<tr>
<td>Flow (steam)</td>
<td>kg/hr</td>
<td></td>
</tr>
<tr>
<td>Length, Level</td>
<td>mm</td>
<td>M</td>
</tr>
<tr>
<td>Time</td>
<td>hr</td>
<td>sec, min</td>
</tr>
<tr>
<td>Heat</td>
<td>kcal</td>
<td>Gcal</td>
</tr>
<tr>
<td>Power</td>
<td>kW</td>
<td></td>
</tr>
<tr>
<td>Fouling resistance</td>
<td>m² hr °C / kcal</td>
<td></td>
</tr>
<tr>
<td>Pipe size / diameter</td>
<td>Inches (in)</td>
<td>Mm</td>
</tr>
<tr>
<td>Mass</td>
<td>kg</td>
<td></td>
</tr>
<tr>
<td>Liquid relative density</td>
<td>sp gr T°C/15.6°C</td>
<td></td>
</tr>
<tr>
<td>Liquid density</td>
<td>kg/m³</td>
<td></td>
</tr>
<tr>
<td>Vapor flowing density</td>
<td>kg/m³</td>
<td></td>
</tr>
<tr>
<td>Furnace draft</td>
<td>mm of WC</td>
<td></td>
</tr>
<tr>
<td>Storage tank pressure</td>
<td>mm of WC</td>
<td></td>
</tr>
<tr>
<td>Vacuum</td>
<td>mm of Hg, mm WC</td>
<td></td>
</tr>
</tbody>
</table>
2.0 DESIGN PRESSURE

2.1 General Rule
Design pressure of Process Static Equipment shall be based on the maximum Operating Pressure. Malfunction and Equipment failure shall be taken into consideration by safety devices. Design pressure shall be selected from the list below. Alternatively LSTK Contractor shall select the design pressures as recommended by the standard engineering practice.

a) For max operating pressure below 2 kg/cm² g use 3.5 kg/cm² g
b) For max operating pressure between 2 kg/cm² g and 15 kg/cm² g use Max. Operating Pressure + 1.5 kg/cm²
c) For Max. Operating Pressure between 15 kg/cm² g and 100 kg/cm² g use Max. Operating pressure x 110 %
d) For Max. Operating Pressure equal and above 100 kg/cm² g use the Maximum Operating Pressure + 10 kg/cm² g. Alternatively LSTK Contractor shall select the maximum operating pressure as recommended by the standard engineering practice.

2.2 Equipment under Vacuum
Equipment normally operated under vacuum is designed for full vacuum and for the highest pressure it can experience in case of vacuum failure. Equipment containing a fluid with a vapour pressure at ambient temperature lower than atmospheric pressure which can be isolated shall be equipped with vacuum breaking device or else be designed for full vacuum. Equipment subject to vacuum due to mal-operation or failure shall be equipped with vacuum breaking devices or else be designed for full vacuum.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Preferred Units</th>
<th>Alternative Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard vapor</td>
<td>Nm³/hr at 0°C &amp; 1.033 kg/cm²</td>
<td></td>
</tr>
<tr>
<td>Standard liquid</td>
<td>m³/hr at 15.6°C</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity</td>
<td>kcal/hr-m-°C</td>
<td></td>
</tr>
<tr>
<td>Heat Transfer coefficient</td>
<td>kcal/hr-m²-°C</td>
<td></td>
</tr>
<tr>
<td>Enthalpy, Entropy</td>
<td>kcal/kg</td>
<td></td>
</tr>
<tr>
<td>Heat rate</td>
<td>10⁶ kcal/hr or MM kcal/hr</td>
<td>Gcal</td>
</tr>
<tr>
<td>Viscosity</td>
<td>cP</td>
<td></td>
</tr>
<tr>
<td>Kinematic Viscosity</td>
<td>cSt</td>
<td></td>
</tr>
<tr>
<td>Sound Pressure</td>
<td>dB(A)</td>
<td>dB(A)</td>
</tr>
<tr>
<td>Sound Power</td>
<td>dB(A)</td>
<td>dB(A)</td>
</tr>
</tbody>
</table>
2.3 **Equipment on the Discharge of a Pump**

Equipment which may have to bear the shut-off pressure of a pump shall have a design pressure equal to or higher than the shut-off pressure. Pump shut-off pressure shall be estimated according to Clause 8.0.

2.4 **Reactor Loops and Similar Process Systems**

For reactor loops and similar process systems the recommendations of API RP 521 Appendix F (latest edition) and API RP 520 Appendix B (latest edition) will be followed.

2.5 **Thin walled Tanks and Vessels**

Atmospheric thin walled tanks and vessels shall have a design pressure equal to the highest pressure imposed upon discharge of the pressure relief device. The design pressure for vacuum shall be equal to the lowest pressure imposed upon suction of the vacuum relief device.

3.0 **DESIGN TEMPERATURE**

Design temperature for process equipment shall be whichever is higher:

a) Maximum operating temperature + 15 °C
b) Boiling temperature at design pressure of process medium inside, if applicable.
c) Design temperature shall be rounded up to full 5°C steps.
d) Design minimum temperature shall be specified only if the minimum operating temperature is below 0 °C. Design minimum temperature shall be 5 °C less than the minimum operating temperature. Special attention shall be given to low boiling liquids.
e) For piping, design temperature shall be determined according to ASME B 31.3.

4.0 **CORROSION ALLOWANCE**

Materials of construction and corrosion allowance for all Equipment and machinery shall be for a design life of 25 years (except for heat exchanger tubes). However, minimum corrosion allowance for carbon steel (including 0.5 Mo alloy steels) shall be:

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Corrosion Allowance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Vessels and other applicable Equipment</td>
<td>3 mm</td>
</tr>
<tr>
<td>Storage Tanks</td>
<td>1.5 mm</td>
</tr>
<tr>
<td>Piping</td>
<td>1.5 mm</td>
</tr>
<tr>
<td>Removable parts or internals (on each side in Contract with operating fluid)</td>
<td>0.75 mm</td>
</tr>
<tr>
<td>For stainless steel/titanium</td>
<td>0 mm</td>
</tr>
<tr>
<td>Carbon steel with epoxy resin coating</td>
<td>3 mm</td>
</tr>
</tbody>
</table>

5.0 **HYDRAULIC RETENTION TIME**

Hydraulic retention time (Hold-up Requirements) is defined between low level (LL) and high level (LH).
<table>
<thead>
<tr>
<th>Type of Service</th>
<th>Retention Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed Surge drum</td>
<td>30 minutes (*)</td>
</tr>
<tr>
<td>Reflux only</td>
<td>5 minutes (*)</td>
</tr>
<tr>
<td>Column Feed on flow control</td>
<td>15 minutes (*)</td>
</tr>
<tr>
<td>On cascade level/flow control</td>
<td>8 minutes (*)</td>
</tr>
<tr>
<td>Re boiling by Fired Heater</td>
<td>8 minutes (*) on feed to heater</td>
</tr>
<tr>
<td>Re boiling by Thermo siphon</td>
<td>10 to 30 seconds on circulation</td>
</tr>
<tr>
<td>PRODUCTS to storage</td>
<td></td>
</tr>
<tr>
<td>Without Pump</td>
<td>5 minutes (*)</td>
</tr>
<tr>
<td>With Pump</td>
<td>7 minutes (*)</td>
</tr>
<tr>
<td>Feeds and Products feeding another Unit</td>
<td></td>
</tr>
<tr>
<td>On flow control</td>
<td>15 minutes (*)</td>
</tr>
<tr>
<td>On cascade/level flow control</td>
<td>8 minutes (*)</td>
</tr>
<tr>
<td>Tanks capacities</td>
<td></td>
</tr>
<tr>
<td>Steam drum (LHH – empty)</td>
<td>Min 10 minutes</td>
</tr>
<tr>
<td>Deaerator Storage Tank</td>
<td>Min 30 minutes</td>
</tr>
</tbody>
</table>

In the case of pumps ensuring several services such as reflux and liquid distillate to storage, the residence time of the corresponding vessel will be whichever is greater from the above list.

(*) To be advised by LSTK Contractor.

6.0 HEAT EXCHANGERS

In general heat exchangers shall be designed to 110 % of their operating duty/flow.

Columns overhead coolers shall be designed to 120 % of their operating duty/flow.

Large heat exchangers shall be split into two or more shells for easy operation and maintenance.

As far as possible AES type of exchangers shall not be used.

7.0 AIR COOLERS:

Air coolers shall be used wherever economically feasible. Air coolers shall be designed for 110 % of the operating duty/flow based on the dry bulb design temperature.

8.0 PUMPS

Normally pumps shall be designed to 110 % (else as defined in individual sections) of their maximum required flow rate in worst case of operation. Pumps for fractionation column reflux, pump round and re-boiler, flow rates shall be designed to 120% of their maximum required flow rates.

The shut-off pressure for piping design shall be estimated according to the following criteria whichever is higher:

a) Differential head at rated flow x 125 %(*) + Max. suction static head + design pressure of vessel of pump suction side.

b) Above calculated design pressure at centrifugal pump discharge must be checked with the shut off pressure based on pump vendor data & higher out of two shall be considered.

(*) shall be corrected as per pump vendor data.
BFW pumps shall be designed for 120% of their maximum required flow rate in worst case of operation. BFW Pump drives, electric motor driven or Steam Turbines may be chosen depending upon plant energy consumption optimisation.

9.0 **COMPRESSORS**
In general, compressors shall be designed to a minimum of 110% (else as defined in the individual sections) of their maximum required flow. However, they are subject to special considerations according to the process. All vent valves and anti-surge valve shall be of leakage Class-V.

10.0 **PRESSURE RELIEF VALVES**
Pressure relief valves shall be supplied with locked open isolating valves except those for IBR service. Pressure relief valves for operational failure shall have installed spares. Also PRV on fire case with Hydrocarbon service shall have installed spare. LSTK Contractor shall take care of any additional requirement as per good engineering practice. The set pressure of pressure relief valves shall be equal to the design pressure of the equipment. All safety valves will have bypass valves except safety valves for IBR service. All pressure relief blows out lines in steam service shall be released to atmosphere at a safe height.

11.0 **COLUMNS AND VESSELS**

11.1 **Nozzle**
   a) Minimum size 3/4” (for S.S shall be 1 inch).
   b) Nozzle rating according to once of connected piping for instrument min. Class 150 ANSI rating.

11.2 **Manhole**
   a) Manhole size 24” (*)
   b) Manhole installation for Tray Tower

For tray towers, manholes shall be provided at top, bottom, feed point and draw-off point of tower and after each 20 trays or after every 15 m elevation distance, whichever is lesser as minimum.

(*) In case there is restriction for diameter, minimum 20” may be used.

11.3 **Hand hole or Inspection hole**
   a) Preferable Size 8 inches
   b) Minimum Size 6 inches

11.4 **Vent and Drain**
Vent and drain for vessels will normally be provided at the minimum length on overhead or bottom line in accordance with the following table:
### Volume or diameter of vessel (m³ or mm) Vent diameter (inches) Drain diameter (inches)

<table>
<thead>
<tr>
<th>Volume or Diameter</th>
<th>Vent Diameter (inches)</th>
<th>Drain Diameter (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V &lt; 75 or D &lt;= 4,500</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>75 &lt; V &lt;= 220</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4,500 &lt; D &lt;= 6,000</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>220 &lt; V &lt;= 420 or D &gt; 6,000</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>V &gt; 420</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: Vent and drain connections are not necessarily located on vessels.

All Columns shall have high efficiency demister for removal of moisture and entrainment.

### 11.5 Steam Out

Steam out nozzles shall be sized as follows:

<table>
<thead>
<tr>
<th>Type of Application</th>
<th>Nozzle Size (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drums and heat exchangers (when applicable)</td>
<td>2</td>
</tr>
<tr>
<td>Column diameter (m), D</td>
<td></td>
</tr>
<tr>
<td>a) D &lt;= 4</td>
<td>2</td>
</tr>
<tr>
<td>b) 4 &lt; D &lt;= 5.5</td>
<td>3</td>
</tr>
<tr>
<td>c) D &gt; 5.5</td>
<td>4</td>
</tr>
</tbody>
</table>

### 11.6 Storage (Chemical)

LSTK Contractor shall consider all facilities necessary for safe loading, unloading, storage and transportation of chemical within the plant Battery limit during Construction stage.

### 12.0 FOULING FACTORS:

The exchanger design shall consider the following minimum fouling factors:

<table>
<thead>
<tr>
<th>Description/Service</th>
<th>Fouling factor (m²°C h/Kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam</td>
<td>0.0001</td>
</tr>
<tr>
<td>DW, BF and BW</td>
<td>0.0001</td>
</tr>
<tr>
<td>Process Condensate stripped/un stripped</td>
<td>0.0001/0.0002</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.0001</td>
</tr>
<tr>
<td>Steam</td>
<td>0.0001</td>
</tr>
<tr>
<td>Boiler blow down</td>
<td>0.0001</td>
</tr>
<tr>
<td>Cooling water (Shell side)</td>
<td>0.0006/0.0002</td>
</tr>
<tr>
<td>Cooling water (Tube side)</td>
<td>0.0004/0.0001</td>
</tr>
</tbody>
</table>
SECTION : VI - 5.2

INSTRUMENTATION

PLANT : STEAM GENERATION PLANT

PROJECT : INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA
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3.0 DESIGN PHILOSOPHY

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3.3 DESIGN REQUIREMENTS
3.3.1 OVERALL CONTROL SYSTEM STUDY
3.3.2 INSTRUMENT CONTROL AND OPERATING PHILOSOPHY
3.3.3 INSTRUMENT DESIGN CRITERIA
3.3.4 EMERGENCY SHUTDOWN PHILOSOPHY
3.3.5 PACKAGE AND SUB-PACKAGE CONTROL PHILOSOPHY
3.3.6 JUNCTION BOXES AND CABLING PHILOSOPHY
3.3.7 FLOW METERING PHILOSOPHY
3.3.8 INSTRUMENT PURGING AND FLUSHING
3.3.9 HEAT TRACING AND INSULATION
3.3.10 INSTRUMENT PAINTING REQUIREMENTS
3.3.11 INTERFACE WITH OWNER FOR SYSTEM INTEGRATION
3.3.12 INTERFACE WITH EXISTING SYSTEM
3.3.13 ELECTRICAL/INSTRUMENTATION INTERFACE
3.3.14 UPS LOAD REQUIREMENTS

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4.2.2.1 SPECIFIC REQUIREMENTS OF DCS& PLC PACKAGE
4.2.2.2 HART MAINTENANCE SYSTEM
4.2.2.3 ANALYZER SYSTEM
4.2.2.4 CCTV MONITORING
4.2.2.5 DELETED
4.2.2.6 EXECUTION METHODOLOGY FOR SYSTEMS
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4.3 INSPECTION AND TESTING
4.4 INSTALLATION, LOOP CHECKING AND COMMISSIONING
4.4.1 INSTALLATION REQUIREMENTS
4.4.2 LOOP CHECKING AND COMMISSIONING
4.4.3 SYSTEM ACCEPTANCE TEST

4.5 CONTROL ROOM
4.6 ANALYZER SHELTER/ROOM

4.7 PACKAGE UNIT INSTRUMENTATION

5.0 MANDATORY SPARES
6.0 CONTRACTOR DATA REQUIREMENTS

7.0 LIST OF ATTACHMENTS

STD-0001 STANDARD SPECIFICATION FOR ANALYSER SHELTER
STD-0002 REQUIREMENTS FOR ANALYSER SYSTEMS
STD-0003 STANDARD SPECIFICATION FOR STACK ANALYSER
STD-0004 STANDARD SPECIFICATIONS FOR ANALYSER SYSTEM
STD-0005 PROCESS STEAM ANALYSER
STD-0006 CALIBRATION GAS REQUIREMENT & UTILITY CONSUMPTION
STD-0020 SPECIFICATION FOR MASS FLOW METER
STD-0097 SPECIFICATION FOR ERECTION TENDER
STD-0098 STANDARD SPECIFICATION FOR PACKEG UNIT
STD-0099 STANDARD SPECIFICATION FOR INSTRUMENTATION WORK
STD-0100 STANDARD SPECIFICATION FOR INSTRUMENT TUBE FITTING
STD-0101 STANDARD SPECIFICATION FOR INSTRUMENT TUBING
STD-0102 STANDARD SPECIFICATION FOR INSTRUMENT VALVES AND MANIFOLD
STD-0103 STANDARD SPECIFICATION FOR JUNCTION BOXES AND CABLE GLAND
STD-0120 STANDARD SPECIFICATION FOR MOTORISED ACTUATOR
<table>
<thead>
<tr>
<th>Document No.</th>
<th>Rev</th>
<th>STD-0122</th>
<th>STANDARD SPECIFICATION FOR GAS DETECTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>STD-0200</td>
<td>DESIGN BASIS FOR DCS /PLC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>STD-0201</td>
<td>STANDARD SPECIFICATION FOR DCS&amp; PLC SYSTEM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>STD-0202</td>
<td>STANDARD SPECIFICATION FOR PLC SYSTEM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>STD-400</td>
<td>STANDARD SPECIFICATION FOR SAFETY RELIEF VALVES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>STD-401</td>
<td>STANDARD SPECIFICATION FOR RUPTURE DISC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>STD-0900</td>
<td>SPECIFICATION FOR CCTV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TS-0821A</td>
<td>FIRE ALARM SYSTEM REQUIREMENTS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TS-0821</td>
<td>TECHNICAL SPECIFICATION COMMUNICATION AND FIRE ALARM CABLES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TS-0822</td>
<td>TECHNICAL SPECIFICATION FIRE DETECTION AND ALARM SYSTEM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>STD-99901</td>
<td>RESPONSIBILITY CHART OF CONTRACTOR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>STD-9993-</td>
<td>TRAINING REQUIREMNT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>STD-9999</td>
<td>INSTRUMENTATION MANDATORY SPARE LIST</td>
</tr>
<tr>
<td></td>
<td></td>
<td>STD-BBBB</td>
<td>SUPERVISORY CONTROL PANELS, SUPERVISORY CONTROL, DEKS, EQUIPMENT PANELS</td>
</tr>
</tbody>
</table>
1.0 GENERAL

This document describes in detail the scope of work, supply and responsibilities of Contractor for carrying out instrumentation activities for this project.

1.1 The description and requirements contained in this specification are concise by necessity and cannot include all details. However, it is the responsibility of the contractor to execute the job on a turnkey basis in accordance with the specifications and internationally recognized good engineering practices for smooth and successful operation of various units of the plant.

1.2 Any activity specifically not listed in this document, does not absolve the contractor of their responsibility to include such activities in their scope of work and supply, which otherwise is necessary, to complete instrumentation work for the steam generation plant. All such activities shall be carried out by the contractor without any implication.

DDCMIS / DCS: Distributed Digital Control Monitoring & Information System / Distributed Control System

2.0 SCOPE OF WORK & RESPONSIBILITY

2.1 Contractor scope of work and responsibility shall be as per STD-99901 (Responsibility chart) and STD-99902 (Scope of supply & installation) attached along with. However details are being elaborated in the following clauses.

2.2 SCOPE OF WORK

2.2.1 Contractor shall be responsible for implementation of complete instrumentation and controls for the PLANT units of refinery on turnkey basis with scope of work as listed below but not limited to the following:

i) Design and Engineering
ii) Procurement/Supply, Factory testing and Acceptance
iii) Installation, field calibration / testing, loop checking, System Integration and Commissioning
iv) Fire Alarm and gas detection system as per attached specification TS821A, TS821, TS822
v) Co-ordination with other LSTK contractors, package vendors and client.
v) Training for Owner Personnel (as per annexure-Training)
vi) DCS, PLC and BMS
vii) HVAC control room
2.2.2 Design and Engineering

a) The contractor shall be responsible to carry out the design and detailed engineering based on the data provided in the process packages and in line with other technical requirements specified elsewhere in this document. Scope shall also include sizing and sizing verification for all items including where data is dependent upon detailed engineering, detailing of basic engineering designs, preparation of data sheets, coordination drawings for instruments and system oriented items, engineering drawings etc.

b) Residual Engineering of process packages

The contractor shall also be responsible for carrying out any residual basic engineering of the process packages necessary for proceeding with detailed engineering like instrument sizing, utility consumption, specifying derived data in process data sheets, type and material selection of instruments wherever required, analyzer room/shelter sizing etc. Instrumentation and control requirements for implementation of recommendations of HAZOP studies shall also be carried out by the contractor. Contractor shall also be responsible for detailing out various sub-package requirements of Package Equipment covered under BEDP / process document.

d) Control Room Engineering

DCS and whole control system for the facility shall be located in dedicated Steam Generation control room, which shall be blast proof. As per the envisaged operating philosophy, the plant operation would be monitored & controlled using DCS control system for meeting the above requirements for DCS necessary Hardware & Software shall be procured to meet the project specific requirements. GPS based master clock shall be provided for time synchronization. HVAC shall be considered for the control room.

e) Control Systems Engineering

Contractor shall be responsible for the selection of DCS & PLC package, provide all engineering inputs to the DCS / PLC vendor & conduct system engineering meetings viz, Kick off meeting, which shall cover System definition, Software definition etc... Contractor shall also responsible for conducting the Factory acceptance test in presence of Process licensor / package vendors at DCS / PLC manufacturer works along with PMC / Owner. Contractor shall carry out the Site acceptance test after Commissioning / proving the units taking all controls in Auto mode for turndown process condition.
The system includes:

i) Distributed Control System (DCS)

ii) Close Circuit Television (CCTV) IP based

iii) Instrument Asset Management System (HART)

iv) Alarm Information Management System (AIMS)

v) LEL/Toxic Detection system

vi) Burner Management System (BMS) (Independent for each steam generation units)

   BMS Shall take care of all the corresponding ESD logics of individual units.

vii) Other systems such as Fire alarm system/Analyzer systems/ Telephone/LAN network etc.

viii) MMS system

ITCC system is not acceptable.

The MMS vendor/LSTK shall submit clause wise compliance of API 670 latest edition. All field Instruments and control system throughout the complete plant to be designed so as to maintain fewer inventories and have interchange ability at any time. Bidder to submit detailed chart for spare parts interchange ability for instruments/control system.

Each Steam generation unit shall have Dedicated BMS system, and shall have dedicated system bus (redundant), which shall be capable to work independently, this BMS system shall take care the ESD functions of independent units.. This shall be connected to DCS system bus (Redundant); All communication in Steam Generation Plant shall be with redundant philosophy,

All the coal handling systems for each Steam Generation units shall be dedicated and shall be working independently.

f) Engineering Drawings & Documents

i) Contractor Data Requirements attached elsewhere indicate the list of drawings and documents required to be supplied by the contractor, as a minimum. Contractor to note that list specifies only the major deliverables. Documents and drawings not listed but necessary for proper engineering, construction, operation and maintenance shall also be prepared by the contractor.

All rights reserved
ii) Contractor shall be responsible for preparation of all engineering drawings and documents including those necessary for construction at site like instrument index, tray & tray layouts, location plans, cable schedules, installation standards, bill of material etc.

iii) Contractor shall also be responsible for providing all drawings and documents for package! Sub package units including those necessary for installation, Pre-commissioning and commissioning activities.

iv) Contractor shall utilise uniform data sheet formats, being enclosed along with this document, for preparing specifications for various instruments, including those which are being prepared by package! Sub package vendors. Items for which no format has been attached with the document, contractor may use standard ISA formats. Use of manufacturer standard formats shall not be used.

v) The contractor shall supply all the documents in both hard copy and CD. This documentation shall include even those all the documentation, which is required for package units.

ix) Loop drawings for loops connected to DCS/PLC shall be prepared by DCS & PLC System vendor based on the information provided by the contractor.

vii) Any discrepancies in case found between various documents e.g. P&IDs and logic diagrams etc., shall be brought to the notice of the owner/PMC. Contractor shall also be responsible to update the documents incorporating the required changes.

g) The design and engineering work shall also include review of post-order vendor drawings and documents for all instruments and system oriented items. Following methodology must be followed for drawings and documents being forwarded to PMC / Owner:

i) The Contractor shall thoroughly review and approve vendor drawing for all instruments including sub-package items, before forwarding to PMC /Owner. Only the approved drawings duly stamped and signed by a competent representative/ engineer of Contractor shall be forwarded.

Licensor shall review selected documents such as purchase requisition for critical items like analysers, and critical documents such as interlock diagrams, Control schemes, Alarm / trip
settings, etc. of Contractor documents. Finalisation of documents based on licensor comments shall also be carried out by the contractor.

Contractor shall be responsible for forwarding the above documents to licensor for their review & approval prior to DCS& PLC system FAT.

ii) All multi-disciplinary fabrication and construction drawings shall be reviewed and signed by contractor’s respective departmental representatives before forwarding to PMC / owner for review /Approval/record.

h) Contractor shall be fully responsible for coordinating all instrument related activities with the agencies concerned to ensure proper, uniform and smooth engineering. This shall include coordination with:

i) All package unit suppliers for uniformity in engineering and documentation supplied by them including P&ID’s, instrument specifications, installation standards etc. and obtaining all requisite drawing and documents for review, record and final documentation.

ii) All instrument item suppliers including suppliers / manufacturers of various system oriented items in contractor’s scope.

iii) Contractor’s own inter-departmental coordination with departments like mechanical, piping, electrical, pressure vessel, heater group etc; This shall include furnishing all necessary engineering data in the form of drawings & documents and review of drawings & data supplied by other departments.

iv) System vendors for System Oriented items, as necessary.

v) Coordination with other field contractors as desired by PMC / Owner at any point of time.

vi) Contractor shall be fully responsible to co-ordinate with the licensor to obtain any kind of details required during engineering.

2.2.3 Procurement/Supply, Factory testing and Acceptance

a) Engineering for procurement shall include preparation of various material requisitions which shall include data sheets, data sheets for instruments, instrument standard specifications, special requirements etc.; evaluation of offers received from various manufacturers/vendors; preparation of Technical Bid Analysis; preparation of purchase requisition and review/approval of vendor drawings, incorporation of PMC /owner comments etc.
b) All items shall be procured from vendor list attached elsewhere in this package. For the items where no vendor list has been attached Contractor shall submit the sub-vendor list for PMC/Owner review for all such type of instruments and system oriented items. Contractor must desist from procuring any items from vendors not approved by PMC/owner. Approval of vendor list must be obtained from the owner/PMC before initiation of procurement for all such items.

c) Contractor shall prepare purchase requisitions for all instruments/systems which shall consist of a consolidated purchase document including all purchase specifications agreed pre-order with vendor/manufacturer including data sheets, special instructions/requirements (if any), standard specifications/purchase specifications, testing requirements, quality requirements etc. All purchase requisitions shall be furnished to PMC/owner for information/review/approval as applicable.

d) Factory Acceptance Test (FAT) and calibration of all instruments shall be carried out by the contractor before despatch. PMC/Owner shall witness testing of any or all items at various stages during manufacture and/or at final stage before shipment at the discretion of PMC/owner. Testing shall be carried out as per approved procedures. Any system-oriented item procured by contractor like analyser system etc, must undergo integrated factory testing at manufacturer/supplier works. No instrument shall leave manufacturer’s works without factory acceptance test. For system oriented items like DCS/PLC/Analyser etc, the FAT shall also be witnessed by the Owner / PMC / Licensor.

2.2.4 Installation, Field Calibration/Testing and Commissioning

a) Installation

i) Contractor shall carry out installation of all instruments as described in this document.

ii) Installation shall include but not limited to installation of DCS & PLC package, Package PLC if any, all field instruments in the unit, including analyser system, CCTV, Fire alarm system, LEL system, all package vendor items, installation of junction boxes, interconnection between instruments and junction boxes, fabrication, laying and painting of cable trays & cable trays, providing cable trench, laying of all single pair and multi pair cables, tagging, ferruling, glanding and pair/core identification of all field cables including
cables to and from MCC, inside the control room cellar area/ analyzer shelters, within
the unit and as per the battery limit defined for the contractor.

iii) Installation of control room mounted equipment including termination of field cables,
powering up of equipment, interconnections within the control room for the control room
shall be in contractor's scope.

iv) Installation of instruments shall be carried out as recommended in the process packages
by process licensor/PMC standards. For special instruments, the installation may be
carried out as per vendor/manufacturer’s recommendations however all such installation
standards shall be subject to PMC/owner review.

For the instruments where installation standards are not available in the licensor’s/PMC
documents, the same shall be prepared by the contractor inline with PMC standards
attached elsewhere in this package. The same shall be subject to PMC/owner’s review.
Any specific requirements specified in the package shall also be taken care of while
finalising these standards.

v) Contractor shall be fully responsible for providing completely integrated unit wide
earthing system for which Instrument earthing system shall be a part. Contractor scope
of work for instrumentation shall include earth pits, earthing cable/strips (as applicable)
etc. as per the requirements of various instruments and field mounted systems including
analysers, DCS/PLC etc

Contractor shall also be responsible for interconnecting instrument earth pits with unit
earth pits (provided by electrical).

b) Testing & Calibration

Contractor scope of work includes testing of all items and systems at site including impulse lines,
instrument air line, pneumatic signal tubes and instrument cables and special instruments items if any.
Contractor shall also carry out calibration of all instruments as per the requirements specified in section 4.4
of this document.

c) Commissioning
i) It is the responsibility of Contractor to co-ordinate and makes available the services of system vendors / sub vendors for system like DCS & PLC Package, Analysers, VMS, Antisurge controller (if applicable) etc. and other special instruments etc. during installation, testing, site acceptance, start-up/ commissioning of the plant.

ii) Loop Testing

Contractor scope of work shall include loop checking of completely integrated instrumentation and control system including package / sub package system items and units for which control system is being supplied by contractor inline with the requirements specified elsewhere in this package. The coordination with any other units contractor (if required) shall be in the contractor scope of work.

iii) System Acceptance at site.

Contractor shall be fully responsible to demonstrate to PMC / owner all functional requirements for the instruments, control system, in their scope of supply as contractor, specified in this document including their performance in the actual plant environment.

Contractor shall be fully responsible to tune all the plant control loops. It is the responsibility of contractor to arrange for licensor’s Instrumentation specialist for logic & Control scheme checking, Commissioning & loop tuning at Site. In any case commissioning can be considered complete only when all control loops are tuned to perform optimally.

It is the responsibility of the Contractor shall maintain the unit for a period of one month taking all the controls in auto & all interlocks on line from day of stabilization of unit.

vi) Start-up, commissioning and stabilisation of plant with PMC / Owner / Licensor / Other EPC Contractors / System vendors like DCS, PLC, Analyzers, CCTV, LEL Gas detection etc. shall be the total responsibility of Contractor. Contractor shall render all possible help and assistance to all agencies involved in completing these activities. Contractor shall also be responsible to co-ordinate all the activities related to their portion of unit with other agencies/ contractors/ owner/ licensor/ PMC as applicable.

2.3 SCOPE OF SUPPLY

2.3.1 Supply of all items related to instrumentation and control systems shall be as indicated on the Piping & Instrumentation diagrams (P&ID) and other technical documents attached with this document.

2.3.2 The scope of supply shall include but not limited to the following as a minimum:

a) All the instruments required and as included within the battery limit of PLANT unit (including all sub-packages like compressors, pumps etc.) like field transmitters & switches, pressure & temperature gauges,
level gauges, theromwells, thermocouples, special thermocouples, special temperature detectors, RTD’s, flow elements, venturi tubes, orifice assemblies, solenoid valves, Control valves with accessories, Safety relief valves, self actuated control valves, Flame arrestors, Desuperheater system, special instruments etc. or any other instrument necessary to make the scope complete.

Supply of DCS & PLC package, which includes Subsystem like HART Maintenance system, AIMS, IAMS, CCTV, Telecom Network and Documentation server etc as per the architecture.

All the System Cabinets (DCS, PLC, Fire system, all other electronics cabinets) shall be installed with proper ventilation system as per standard design so as to maintain suitable required temperature required for proper functioning of installed Electronics

Supply of Vibration Monitoring system, LEL gas detection system & Package vendor Instrumentation.

b) For the control systems like Analyser System etc. contractor scope shall include supply of all items including their integration with the DCS system.

c) All installation and erection materials such as impulse piping, pipe fillings and valves, tubing, tube fillings, cable perforated aluminium tray/tray and supports, all type of consumables and accessories for mounting of instruments, instrument supports, canopies/sunshields for all field mounted instruments of PLANT units under contractors scope.

d) Supply of all types of cables such as signal, alarm, control, thermocouple extension, RTD, Gas detector cables, power cables, special cables (like for speed governors, analyser cables etc.) as necessary. LSTK CONTRACTOR shall refer to the overall plot plan for information related to location of PLANT unit of this package. Based on the information, contractor shall estimate the requirement of trays / trays and multi pair / single pair and special cable lengths.

e) Main cable GI tray/trench, perforated tray, angle tray, structural supports, consumables for cable laying and routing within respective units, their interface with other EPCC/field contractors for cable routing up to the main control room through cable rack / trench. The scope shall also include supply of cables, trays, trays for routing of cables within cable cellar area and upto cabinets/panels/ racks in the rack room including supply of all structural support required and found necessary. All cable trays shall be installed above ground or overhead as applicable.

f) All system cables/fiber optic cables in the field (including communication between CCR,CR and main fire control station) shall be routed in HDPE Hard pipe. Fillings shall be used for joining the HDPE pipe. HDPE pipes shall be ORANGE in colour with BLACK fillings. All system cables/fiber optic cables shall be routed in the middle 150mm portion of the tray. Wherever it is absolutely necessary to route these cables underground, it should be routed in the RCC Trenches only. Separate route should be followed for redundant system cables. Supply of Cable trays and laying of cables through trenches upto CCR are in bidder scope.

g) Separate junction boxes and cable glands for different types of signals such as intrinsically safe and non-intrinsically safe 4-20 mA dc, thermocouple, RTD, shutdown, alarm, power etc.

h) All piping & pipe fittings, tubes & tube fillings for instrument air supply distribution and steam tracing etc.

i) Insulation and painting of instruments and impulse lines as required in line with the insulation and painting specifications attached elsewhere in this document.
j) Local Control panel/Local gauge boards & accessories (as applicable).

k) Galvanised iron / copper earthing strip and earthing cables for earthing of all instrumentation items including junction boxes etc. to electrical earthing strip in the unit and instrument earthing system as applicable.

l) Supply of MCT blocks and frames for cable entry to control room/analyzer shelters for each unit as applicable.

m) Supply of analyzer shelters as per this document

n) Any other erection material necessary for installation and commissioning of special instruments, if any.

o) Any special tools or tackles for instrumentation

p) Supply of all types of configurators like for field smart transmitters etc. in quantities indicated in this document

q) Supply of spare instruments (e.g. installed, engineering, consumable, mandatory etc.) as listed given elsewhere in this document

r) Supply of drawings and documents as listed elsewhere.

2.3.3 The following criteria shall be also be followed in design and supply.

a) There shall be independent BMS system for each steam generation units, The BMS PLC shall be SIL-3 certified TMR/QMR as per attached specification

b) All control and monitoring of entire plant such as burners, turbines, effluent treatment plant, cooling tower, DM water storage tank, BFW feed pump, Deaerator etc. pertaining to SGP shall be implemented in DCS. The DCS shall be DMR system

c) Deleted

d) Any conveyor system, if applicable, it shall also be automatic and PLC based DMR system Non-SIL.

e) LSTK shall provide complete Steam and water analysis system (SWAS). Silica analyzer of HACK make is preferred. Analysers shall be single channel. SWAS Analysers shall be as per following:

i) Superheated Steam : pH, Specific Conductivity, Cation Conductivity, Silica

ii) Saturated Steam : pH, Specific Conductivity, Cation Conductivity

iii) Blow Down Water: : pH, Cation Conductivity, Silica, Do2

Apart from above, Phosphate analyser shall also be provided. Location can be decided during detail engg.

f) LSTK shall provide all the relevant analysers(e.g. SOx, Nox, CO, CO2, SPM, O2, Unburned Hydrocarbon etc) applicable to the system as per latest(at the time of commissioning) CPCB/State Pollution control boards requirements.

g) Gas detectors shall be provided.
h) Fire Alarm system for all the rooms and fire prone areas
i) CCTV system shall be provided. The system will be guided through CCTV with adequate number of cameras
j) Packaged Air conditioning (HVAC) of control rooms. It shall be designed considering the equipment heat loads, solar heat loads, heat gain into the room, adequate no. of air changes etc. to maintain a uniform temperature and relative humidity within the air conditioned areas.

k) Air Conditioning System

l) All cabling, earthing and lightning protection

m) Adequate furniture in forms of consoles, printer tables, chairs etc shall be provided for control rooms. (Furniture shall be of Godrej Make).

n) All the Instruments as per flow schemes/diagrams and relevant tender drawings, corresponding Mechanical sections and meeting redundancy and other requirements specified under technical specifications are to be provided as a minimum.

o) All Instruments which are Integral to equipment required for control, monitoring and operation of the equipment/plant/ Systems are to be provided. All the instruments shall be provided by the Contractor to meet actual system requirements subject to Employer’s approval.

p) Control Room building shall have 1.5 mtrs minimum false flooring for cable laying. It shall have minimum Manager Room, Shift In charge room, Instrument Maintenance room, Instrument Calibration room, Engineering Room, UPS room, EPABX room, Dining Space/Pantry Room, one ladies and gents toilets. Cable entry to building will be through MCT blocks.

q) Cable entry at the bottom of panels shall be also through cable glands or MCT blocks.

r) Separate earthing for instrumentation earth and panel earth completely separate from Electrical earth to be provided.

s) Local control panel and Junction boxes shall be provided with IP:65 degree of protection

t) All field mounted electronic/ non electronic instruments shall be provided with weather and dust proof protection of IP-65 or better

u) Pneumatic Receiver Instruments shall have receiver elements design for 0.2-1 kg/cm2 g / 3-15 PSI input signal

v) All Instrument Air sub branch to instruments shall be through 1/2” SS pipe whereas main air header coming to product plant shall be 2” to 4” SS pipe as per individual requirement

w) The Control & Instrumentation shall be furnished, erected and commissioned and all other services shall be performed by the bidder as covered under this specification

x) All the Measuring instruments

y) DCS including, modulating controls, interlocks & protection sequential controls, data acquisition.

z) BMS system for individual units (SIL 3 QMR/TMR) No scale Down versions are acceptable
aa) PLC

bb) Deleted

c) Steam and Water Analysis System, Gas Monitoring and Boiler Emission System

d) Control System for Steam Turbine

2.4 Deleted

2.5 DESIGN BASIS

Order of priority for Instrumentation

In the event of conflict between requirements of any two clauses or specification documents, the more stringent requirements shall apply unless confirmed otherwise by the Owner in writing before the award of this contract based on a written request from the Bidder for such clarification.

Hazardous Area classification

- Hazardous Area classification for Instruments shall be Zone 2, IIC, T6. (Where T6 not available then T5/T4 can be used) All instruments shall be intrinsically safe EExib.

- If intrinsically safe item is not available for any instruments, then it must be Flame proof / Ex. Proof EExd.

Electrical / Electronic instruments: IP 67
Sensors; RTD, T/C, etc.: IP 65
Local Gauges; PG, etc.: IP 55
Pneumatic instruments: IP 54
Solenoid valves: IP 67
Local Panel / Skid Mounted Panels: IP 55

EMC compatibility and electrical safety as per latest IEC standard.

Certification for installation in hazardous areas in accordance with IEC 60079 series is shown below:

<table>
<thead>
<tr>
<th>Component</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitters, positioners, I/P converters, etc.</td>
<td>EExib IIC T6</td>
</tr>
<tr>
<td>Switches</td>
<td>EEx de IIC T6</td>
</tr>
<tr>
<td>Analysers and Panels</td>
<td>EEx p IIC T6</td>
</tr>
<tr>
<td>Solenoid Valves</td>
<td>EEx d IIC T6 (Ex md not allowed)</td>
</tr>
<tr>
<td>Junction Boxes and Cable Glands</td>
<td>EEx d IIC T6</td>
</tr>
</tbody>
</table>

Control system/PLC for Coal handling/Material handling/ DM water (Bidder’s scope if applicable) / Condensate polishing unit (Bidder’s scope if applicable) shall be DMR non-SIL. Instruments shall be as follows (as applicable):

- All Smart Petitioners: SIL 2
- All Transmitters: SIL 2
All Solenoids SIL 3
All Gas Detectors SIL 2

**ELECTRICAL SUPPLY**

The electrical supply will be as follows:

- **Distributed Control System, trip system, and Control Room Instruments**: 115V AC
- **Solenoid Valves**: 115V AC / 24V D.C
- **Local Panels**: 115V AC / 24V D.C
- **Local Illumination, equipment for air conditioning, space heaters, Ventilation of local panels and similar purposes**: 240V AC
- **Field-mounted Transmitters and switches**: 24V D.C intrinsic safe
- **Safety Circuits**: 115V AC

The 115V AC supply will be an uninterrupted power supply (UPS) of 115V +/- 10%, 50Hz +/- 3%. Where 24V DC is needed, it will be generated by local rectifier units, which are part of the instrumentation supply. The power supply to these units shall be taken from the UPS. Where 24V DC are used for Safety Circuits, the rectifier units shall be duplicated and with high reliability and form a part of ESD vendor. Redundant 24V D.C. power supply shall be powered from two different sources of UPS. A separate instrument earthing system apart from the power supply protective earthing system is foreseen.

There shall be minimum 4 separate earth pits for System, Panel /power and Intrinsic safe signals with different cable colour codes. All earth shall be less than 2 Ohm or OEM specific, if better. The size of Earthing Cable shall be 50 sq.mm minimum and should be routed in proper HDPE conduit, outside the control room building. All above instrument earth pits shall be separate from Electrical earth pits and must have separate colour identification from electrical earths. Minimum 2 nos. Of earth pits of each type (total 8 nos) shall be constructed.

Two separate AC distribution board (Dual ACDB) fed from parallel redundant UPS are essential for Instrumentation power distribution system for the improved reliability. Each DCS or DCS/ESD AC DB shall be fed from redundant UPS feeders & shall have with static switch for change over automatically without power interruption in case of any incomer failure.

UPS supplies shall not be used for utilities supplies cooling fans, panel/cabinet lighting etc. A separate non-UPS supply shall be used for the same. A summary of all critical UPS alarms shall necessarily provided in DCS and hardwired annunciation in control room or any manned location. Only copper cables & tin-plated copper lugs shall be considered for instrumentation power distribution system.

UPS battery backup should be available for a minimum period of 60 minutes at full load condition. The same to be ensured during capacity discharge test of battery bank during pre-commissioning activities. Protection coordination with respect to fuse/MCB ratings from the supply source ACDB/DCDB to downstream distribution panels shall be thoroughly studied by the system designers/OEM and documented as a part of the system documentation and be implemented accordingly.
### ACCURACY OF INSTRUMENTS

Accuracy of the Instruments shall be minimum as follows:

<table>
<thead>
<tr>
<th>Type of Instrument</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Differential pressure &amp; Pressure transmitter - SMART</td>
<td>± 0.075% of span within TD ratio of 1: 10</td>
</tr>
<tr>
<td>- Variable area type flow meter with transmitter</td>
<td>± 2.0% FS Note (1)</td>
</tr>
<tr>
<td>- Vortex flow meter</td>
<td>± 1.0% FS</td>
</tr>
<tr>
<td>- Positive displacement flow meter</td>
<td></td>
</tr>
<tr>
<td>- Raw material and Product</td>
<td>± 0.2% FS</td>
</tr>
<tr>
<td>- Others</td>
<td>± 0.5% FS</td>
</tr>
<tr>
<td>- Turbine meter or Mass flow meter</td>
<td></td>
</tr>
<tr>
<td>- Raw material and Product</td>
<td>± 0.2% FS</td>
</tr>
<tr>
<td>- Others</td>
<td>± 0.5% FS</td>
</tr>
<tr>
<td>- Magnetic type flow meter</td>
<td>± 0.5% FS</td>
</tr>
<tr>
<td>- Mass flow meter (Coriolis Type)</td>
<td>± 0.2% FS</td>
</tr>
<tr>
<td>- Ultrasonic type flow meter</td>
<td>± 0.5% FS</td>
</tr>
<tr>
<td>- Ultrasonic type flow meter (4 – path)</td>
<td>± 0.52 FS</td>
</tr>
<tr>
<td>- Displacement type level indicator</td>
<td>± 1.0% FS</td>
</tr>
<tr>
<td>- Displacement type level transmitter</td>
<td>± 0.2% FS (Smart)</td>
</tr>
<tr>
<td>- Tank gauge</td>
<td>± 1.0% FS</td>
</tr>
<tr>
<td>- Servo type tank gauge</td>
<td>± 2 mm (up to 20 m height)</td>
</tr>
<tr>
<td>- Radar type tank gauge</td>
<td>± 1 mm or better for custody transfer</td>
</tr>
<tr>
<td></td>
<td>± 5 mm or better for normal application</td>
</tr>
<tr>
<td>- Draft range Pressure transmitter - SMART</td>
<td>± 0.15% of span within TD ratio of 1: 10</td>
</tr>
<tr>
<td>- Diaphragm seal transmitter - SMART</td>
<td>± 0.2% of span within TD ratio of 1: 10</td>
</tr>
<tr>
<td>- Pressure gauge</td>
<td>± 1.0% FS</td>
</tr>
<tr>
<td>- Temperature Transmitter</td>
<td>± 0.2% of calibrated span for RTD</td>
</tr>
<tr>
<td></td>
<td>± 0.5% of calibrated span for Thermocouples</td>
</tr>
<tr>
<td>- Filled system/Bimetallic</td>
<td>± 1.0% FS</td>
</tr>
<tr>
<td>- Small size pressure gauge</td>
<td>± 3.0% FS</td>
</tr>
<tr>
<td>- Draft gauge</td>
<td>± 3.0% FS</td>
</tr>
<tr>
<td>- Receiver gauge</td>
<td>± 1.5% FS</td>
</tr>
<tr>
<td>- Thermocouple &amp; Resistance Bulb</td>
<td>Applicable Codes/Standards</td>
</tr>
</tbody>
</table>

Note: 1. Vendor's standard accuracy is applied to local indicator type
Remarks: 1. Accuracy of instrument and special articles except for the above mentioned instrument shall be in accordance with the applicable codes/standards, or Vendor's standards as approved by Purchaser.
   2. FS: Full scale.
   3. Overall rangeability of transmitter except for draft range shall be 1: 100. Draft range transmitter rangeability shall be 1: 30 for the accuracy indicated above.

PREFERRED ANALYSIS METHODS FOR PROCESS ANALYSERS.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>Electrochemical reaction</td>
</tr>
<tr>
<td>Conductivity</td>
<td>Electrochemical reaction</td>
</tr>
<tr>
<td>Dissolved O2</td>
<td>Electrochemical reaction</td>
</tr>
<tr>
<td>Total Organic Carbon</td>
<td>Thermal Reactor based.</td>
</tr>
<tr>
<td>Oil in Water</td>
<td>Thermal Reactor based TOC analyzer. Quartz Crystal Technology</td>
</tr>
<tr>
<td>Moisture</td>
<td>Tunable Diode Laser Absorption Spectroscopy  Aluminum Oxide for Liquid application only</td>
</tr>
<tr>
<td>Dew point</td>
<td>Quartz Crystal Technology</td>
</tr>
<tr>
<td></td>
<td>Aluminum Oxide</td>
</tr>
<tr>
<td>Gas Chromatography –</td>
<td></td>
</tr>
<tr>
<td>Single stream single component</td>
<td>GCs with inbuilt EPC and Man Machine interface &amp; Ethernet Connectivity.</td>
</tr>
<tr>
<td>Gas Chromatography –</td>
<td></td>
</tr>
<tr>
<td>Single stream multi component</td>
<td>GCs with inbuilt EPC and Man Machine interface &amp; Ethernet Connectivity (Parallel Chromatography Technique)</td>
</tr>
<tr>
<td>Flashpoint</td>
<td>Direct measurement of Flash Point (non catalyst-type detection); Analyzer should correlate with ASTM D-56 and D-93 standards.</td>
</tr>
<tr>
<td>Continuous Distillation Analyzer</td>
<td>should correlate with ASTM D-86 and D-1160</td>
</tr>
<tr>
<td>Pour point Analyzer</td>
<td>should correlate with ASTM D-97 and IP-15</td>
</tr>
<tr>
<td>SOX/NOX</td>
<td>Dilution technique</td>
</tr>
<tr>
<td></td>
<td>UV Fluorescence - for SO2 measurement</td>
</tr>
<tr>
<td></td>
<td>Chemiluminescence - for NOX measurement</td>
</tr>
<tr>
<td>H2S</td>
<td>UV Absorption</td>
</tr>
<tr>
<td></td>
<td>Pulse Ultraviolet Fluorescence</td>
</tr>
<tr>
<td>O2 (Trace)</td>
<td>Electrochemical for samples with Hydrocarbon background &amp; Zirconia for samples with Inert gas as background</td>
</tr>
<tr>
<td>O2 (extractive)</td>
<td>Zirconia closed coupled analyzers</td>
</tr>
<tr>
<td>O2 (Insitu)</td>
<td>Zirconia type</td>
</tr>
<tr>
<td>O2/CO2</td>
<td>Closed coupled Zirconia analyzer with Combustible sensor</td>
</tr>
<tr>
<td>O2/CO2</td>
<td>Extractive type Single analyzer with DUAL analytical modules</td>
</tr>
</tbody>
</table>
Opacity Across the stack, based on Transmissiometry, In situ probe type

Hydrogen
Extractive type analyzer based Thermal conductivity detector for binary type gases
Extractive type Thermal conductivity detector Gas Chromatograph type for Multi gas application

Methane (CH4)
Extractive type analyzer with NDIR analytical module

Hydrocarbon
FID type extractive type analyzer

Sulphur in liquid
Extractive UV Fluorescence based Analyzer

Specific Gravity
Extractive with integrated Sample system with Vibrating Spool Density, Pressure and Temperature measurement

Gas Density
Vibrating Spool type

Liquid Density
Vibrating Tube type

Viscosity
Correlates with ASTM D-445 in accordance with Hagan-Poiseuille principle

Calorific Value / Wobbe Index
Micro GC, Calorimeter

RON, MON, FP, PP
Near Infra Red (NIR)

Color analyzer
Near Infra Red (NIR)

Mass Spectrometer
Magnetic Sector Based

The unit shall install online Continuous Stack Emission Monitoring Systems (CSEMS) at all the stacks of the plant for online real time monitoring for PM, SO2 and Flouride as minimum and data transmission through GPRS system to SPCB RTDAS server and also upload data for use by CPCB.

Bidder to ensure that tapping location on Stack (height at which it is taken) of SPM analyzer is as per latest CPCB guidelines.

Bidder shall supply required hardware and software for connecting these analyzer to the CPCB/State PCB portal with min. 20% spare points for future use. Analyzer shall have RS485/ Ethernet / Modbus connectivity
### Instrumentation

<table>
<thead>
<tr>
<th>Gas</th>
<th>Accuracy</th>
<th>Response</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>H2</td>
<td>+/-2% F.S</td>
<td>+/-2% F.S.</td>
<td>+/-1% F.S.</td>
</tr>
<tr>
<td>SO2</td>
<td>+/-2% F.S</td>
<td>+/-2% F.S.</td>
<td>+/-2% F.S.</td>
</tr>
<tr>
<td>NOx</td>
<td>+/-2% F.S</td>
<td>+/-2% F.S.</td>
<td>+/-1% F.S.</td>
</tr>
</tbody>
</table>

Note: The individual process data sheet or specification sheet shall be followed for method of analysis unless specified.
STANDARDS TO BE FOLLOWED

Design and terminology shall comply, as a minimum, with the latest edition prior to the date of purchaser's enquiry with following codes, standard practices and publications:-

**AGA**
American Gas Association
- Report No.3 - Orifice Metering of Natural Gas & other related hydrocarbon fluids
- Report No.9 – Measurement of Gas by Ultrasonic Meter

**ANSI/ASME**
American National Standards Institute/American Society of Mechanical Engineers
- B 1.20.1 Pipe Threads General Purpose (Inch)
- B 16.5 Pipe Flanges and Flanged Fittings
- B 16.20 Metallic Gaskets for pipe Flanges, Ring Joint, Spiral wound and Jacketed.
- ANSI /ISA - S 7.3 Quality standard for instrument air
- ANSI MC 96.1 Temperature measurement thermocouples
- ANSI/ISA - S 5.115.3 Instrumentation symbols and identification
- ANSI/ISA S 75.01 Flow equations for sizing control valves
- ANSI/ISA S 75.02 Control Valve procedure capacity test
- ANSI/ISA S 75.03 Uniform Face to Face dimensions for flanged globe valve bodies
- ANSI B40.1/ASME Gauges and Pressure Indicating Dial Type Elastic Element
- ANSI/ASME B16.36 Orifice Flanges

**ANSI/FCI**
AnSI B16.104/FCI 70.2 Control valve seat leakage classification

**API**
American Petroleum Institute
- API 520 Sizing, selection and installation of pressure relieving devices in Refineries.
  - Part-I - Sizing and selection
  - Part-II - Installation
- API 521 Guide for pressure relieving and depressurizing systems.
- API 526 Flanged steel Pressure Relief Valves.
- API 527 Seat tightness of Pressure Relief Valves.
- API RP 551 Process Measurement Instrumentation
  - Part I - Process Control and Instrumentation
- API S 1101 Measurement of Petroleum Liquid Hydrocarbon by Positive Displacement meter.
- API S 2000 Venting Atmospheric and low-pressure storage tank nonrefrigerated and refrigerated.
- API S 2534 Measurement of liquid hydrocarbons by turbine meter systems
- API S 670 Vibration, Axial-Position and Bearing-Temperature Monitoring Systems
- API RP 550 Manual on installation of refinery instruments and control system
- API RP 551 Process Measurement Instrumentation
- API RP 552 Transmission Systems
- API RP 553 Refinery Control Valves
- API RP 555 Process Analysers
- API RP 557 Guide to Advance Control Systems
- API RP 554 Process Instrumentation & Control
ASME American Society of Mechanical Engineers

ASME B16.5 Pipe Flanges and Flange Fittings
ASME B16.10 Face-to-Face and End-to-End Dimensions of Valves
ASME B16.11 Forged steel fittings, socket welding and threaded
ASME B 16.25 But welding ends
ASME B 16.34 Valves-Flanged threaded and welding end and annexure for radiography and magnetic particle procedure and acceptance standards.
ASME B16.47 Large Diameter Steel Flanges (NPS 26 thru NPS 60)

ASTM American Society for Testing and Materials

ASTM E 230 EMF tables for standardized thermocouples
ASTM E 608 Standard specification for metal-sheathed base-metal thermocouples
ASTM E 608 Face-to-Face and End-to-End Dimensions of Valves

BS British Standards

BS-5308 Part-II Specification for PVC insulated cables.
BS-7244 Flame Arrestors.
BS 3463 Observation and Gauge Glasses for Pressure Vessels
BS 1042 Section 1.2 Specs for square edged orifice plates and nozzles and venture tubes and inserted in circular cross section conduits.
BS 1042 Section 1.1 Specs for square edged orifice plates and nozzles and their orifice plate and board inlets

DIN German Standards

DIN-43760 Temperature Vs Resistance curves for RTDs.
DIN-19234 Electrical Distance Sensors; DC interface for Distance Sensor and Signal Converter.

EN-10204 Inspection Documents for Metallic Products

IBR Indian Boiler Regulations

IEC International Electrotechnical Commission

IEC 60085 Thermal Evaluation and Classification of Electrical Insulation.
IEC 60332 Test on bunched wires or cables. Part III Cat. A
IEC 60529 Degree of protection provided by enclosures.(IP code)
IEC 60534-2 Industrial Process Control Valves-Flow capacity.
IEC 60584-2 Thermocouple Tolerances
IEC 60751 Industrial Platinum Resistance Thermometer Sensors
IEC 61000-4 Electromagnetic compatibility for Industrial Process measurement and control equipment.
IEC 60079 Code of Practice for the Selection, Installation and Maintenance of Electrical Apparatus for use in Potentially Explosive Atmospheres
<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 60534.1</td>
<td>Control valve terminology and general considerations</td>
</tr>
<tr>
<td>IEC 60534.2.1</td>
<td>Flow capacity - Sizing equations for fluid flow under installed conditions</td>
</tr>
<tr>
<td>IEC 60534.2.3</td>
<td>Flow capacity - Test procedures</td>
</tr>
<tr>
<td>IEC 60534.2.4</td>
<td>Flow Capacity - Inherent flow characteristics and rangeability</td>
</tr>
<tr>
<td>IEC 60534.2.5</td>
<td>Flow capacity - Sizing equations for fluid flow through multistage control valves with inter stage recovery</td>
</tr>
<tr>
<td>IEC 60534.3.1</td>
<td>Face-to-face dimensions for flanged, two-way, globe-type, straight pattern and centre-to-face dimensions for flanged, two-way, globe-type, angle pattern control valves</td>
</tr>
<tr>
<td>IEC 60534.3.2</td>
<td>Face-to-face dimensions for rotary control valves except butterfly valves</td>
</tr>
<tr>
<td>IEC 60534.8.3</td>
<td>Industrial Process Control Valves - Aerodynamic Noise Prediction</td>
</tr>
<tr>
<td>IEC 60534.8.4</td>
<td>Industrial Process Control Valves – Prediction of Noise Generated by Hydrodynamic Flow</td>
</tr>
<tr>
<td>IEC 60584-1</td>
<td>Thermocouples-Part 1: reference table</td>
</tr>
<tr>
<td>IEC 60751</td>
<td>Industrial Platinum Resistance Thermometer Sensors</td>
</tr>
<tr>
<td>IEC 61000.4.1</td>
<td>Testing and Measurement techniques- Overview</td>
</tr>
<tr>
<td>IEC 61000.4.3</td>
<td>Testing and Measurement techniques- Radiated, Radio Frequency, Electromagnetic Field Tests</td>
</tr>
<tr>
<td>IEC 61000.4.4</td>
<td>Testing and Measurement techniques- Electrical Fast Transient/burst Immunity Tests</td>
</tr>
<tr>
<td>IEC 61000.4.5</td>
<td>Testing and Measurement techniques – Surge Immunity</td>
</tr>
<tr>
<td>IEC 61508</td>
<td>Functional Safety of Electrical, Electronic, Programmable Electronic Safety Related Systems</td>
</tr>
<tr>
<td>IEC 61511</td>
<td>Functional Safety of Safety Instrumented Systems for the Process Sector</td>
</tr>
</tbody>
</table>

**IEEE**

C37.90.1 - 2002 Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems

**IS**

**Indian Standard**

IS-5 | Colours for ready mixed paints and enamels
IS-319 | Specification for free cutting Brass bars, rods and sections
IS-1239 | Mild steel tubes, tubulars and other wrought steel fittings.
IS-1271 | Specification of Thermal Evaluation and Classification of Electrical Insulation
IS-1554 | PVC insulated (heavy duty) electric cables working Part I - voltage up to and including 1100V
IS-2074 | Ready mixed paints, air drying, red oxide - zinc chrome
IS-13947 | Degree of Protection provided by Enclosures for Low Voltage Switchgears and Control gears. Part 1 General Rules.
IS-2148 | Flame proof enclosures for electrical apparatus for Explosive Gas Atmospheres – Flameproof Enclosures ‘d’.
IS-3624 | Specification for pressure and vacuum gauges
IS-5831 | PVC insulation and sheath of electric cables.
IS-7358 | Specifications for Thermocouples

**ISA**

**Instrumentation, Systems and Automation Society**

S-5.2 | Binary logic diagrams for process operations.
S-7.3 | Quality standard for instrument air
S-75.01 | Flow equations for sizing control valves
ISA 18.1 | Annunciator sequences and Specifications
ISA S84-01-1996 | Application of Safety Instrumented Systems in the Process Industries
ISA5.2 | Binary Logic Diagrams for Process Operations
ISA5.3 | Graphic symbols for distributed control/shared display instrumentation, logic and computer system

All rights reserved
ISOISO 5167  Measurement of fluid flow by means of orifice plates, nozzles and venturi tubes inserted in circular cross-section conduits.


ISO 5208  Pressure Testing of Valves

NACE  National Association of Corrosion Engineers

NACE MR0175/ ISO 15156  Petroleum & Natural Gas Industries – Material for Use H2 S-Containing Environments in Oil & Gas Production

NACE MROI03-2007  Instruments used in Sour-environment

CENELEC  CENELEC EN 50014  Electrical Apparatus for potentially explosive atmosphere-General Requirements

CENELEC EN 50016  Electrical Apparatus for potentially explosive atmosphere-Pressurized Apparatus “P”

CENELEC EN 50018  Electrical Apparatus for potentially explosive atmosphere-Flame proof enclosure “d”

CENELEC EN 50019  Electrical Apparatus for potentially explosive atmosphere-Increased safety “e”

CENELEC EN 50020  Electrical Apparatus for potentially explosive atmosphere-Intrinsic Safety “I”

NFPA  National Fire Protection Association

NFPA-496  Purged and pressurized enclosures for electrical equipment.

OSHA  Occupational Safety and Health Authority.

SAMA  Scientific Apparatus Maker’s Association

Units of Measurement and Accuracy of Instruments

The units of measurement, graduation of scales and charts shall be in accordance with the following table:

<table>
<thead>
<tr>
<th>Measured variable</th>
<th>Unit of measurement</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>deg Celsius</td>
<td>Direct reading</td>
</tr>
<tr>
<td>Pressure &amp; Diff. Pressure</td>
<td>mm of WC, kg/cm2g,</td>
<td>Direct reading</td>
</tr>
<tr>
<td>Draft pressure</td>
<td>mm of H₂O</td>
<td></td>
</tr>
<tr>
<td>Vacuum pressure</td>
<td>mm of Hg, mm of WC,</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td>kg/cm2a</td>
<td></td>
</tr>
</tbody>
</table>
1. DCS& ESD system as per attached DCS / PLC Architecture is to be used by the LSTK Contractor, for Steam Generation Plant. All DCS& PLC system can be housed in the same control room.

2. Control room Floor level shall be 1.5 meter from the Finished floor Level.

3. Cable Entry to: Control Rooms, Analyser Rooms etc shall be by using MCT Blocks

4. All Analysers, GCs, Mass-Spectrometer shall be Ex.proof irrespective area of installation.

5. **Analyser Shelter**:

   - The LSTK contractor shall house the process analyzers and other analyzers (Control units) in analyser shelter. The construction of each analyzer house shall be prefabricated in press-formed stainless steel sheet. The materials of construction shall have a fire resistance of two hours minimum in accordance with UL 555 and NFPA Standard 90A.
   - HVAC system shall be dual type without any shared components. One shall be working and other standby.
   - Analyser shelter shall have complete redundant air conditioning, venting, heating and/or house pressurization system
   - The analyzer house size shall take into consideration the size of each analyzer plus an allowance for 30% spare on both inside and outside walls for future analyzer and sample conditioning systems
   - Shelters shall be equipped with all safety measures like panic bar at the doors, Emergency alarm push buttons, LEL gas (hydrocarbon) detectors, Fire detection system, warning panels, Fire extinguishers, wash...
basin etc.

- A PLC shall be provided to execute safety logics. PLC shall have redundant CPU. PLC shall be mounted in Ex-proof enclosure. PLC fault shall be annunciated
- Each analyzer house shall have common fresh air intake via a stack mounted on the analyzer house roof. These stacks shall be provided with a rain hood and a mesh to prevent entry of birds etc. also adds tie bars for support of stack. The air shall be drawn from a non-hazardous area and the air intake location shall be at least 1 meter outside the hazardous area. The design of the intake tray and the diameter and length shall be sized by Seller so as to limit the air velocity inside the traying to a maximum of 8m/second. The intake stack shall have filters 5 microns down to 99% efficiency, fire dampers and louvers

6. Internals of All Control Globe / Ball / Butterfly valves, On-off valves, MOV Ball, MOV gate, MOV butterfly valves, MOV Check Valves, Pressure relief valves, Thermal relief valves valves shall be minimum SS316 irrespective of licensor’s data sheet.

7. All control valves / On – Off Valves / MOVs shall be flanged type

8. Control valve / on-off valve, pneumatic valve shall be designed for minimum 4 Kg/cm² air pressure

9. Deleted

10. Thermocouples shall be duplex type.

11. Deleted

12. Temp transmitter shall be used for both open loops & Closed loops.

13. Guided wave radar type instruments (SMART) shall normally be used for level measurement, wherever guided wave radar cannot be used then only external displacer type/Differential pressure type transmitter to be used. Differential pressure transmitter (Capillary type) shall be used for level measurement. Capillary type DPTs shall not be used in vacuum services. Internal displacer type of level transmitters shall not be used.

14. Air distribution pots shall be of stainless steel. Inst. Impulse pipes for process parameters shall be in accordance with piping specifications

15. Perforated aluminium Cable trays to be used.

16. Main instrument air header and Branch header material : SS304

   a. Main instrument air header shall be at least 2" (SS) minimum depending on requirement. It shall have 1" minimum takeoff (SS) with Gate type isolation valve (SS) & further distribution for each instrument through separate ½” SS line with ½” SS Ball valve single piece design with SS handle & with 6 mm OD SS316 tubing.

   b. Inst. Air isolation valve for each instrument: SS304

17. Limit switches shall be proximity type, micro switches shall be avoided

18. All Field Instruments including Gas detectors shall be SIL-2 certified.

19. Hart Compatible gas-detectors to be provided.
20. All line mounted instruments like in-line SOVs, Magnetic flow meter, Rotameter, Mass flow meters etc shall be provided with block & bypass arrangement.

21. Separate Tapping shall be used for each instrument coming for trip, control & monitoring, local display.

22. Separate Sample handing system shall be used for each analyzer. Multi Channel with stream selector can be used, provided the total system including sample handling system shall be imported. Necessary sequence shall be inbuilt in the analyzer for draining the condensate.

23. For double acting valve, air accumulator shall be used for achieving fail safe operation.

24. FRP Canopies are required for Transmitter, JBs, LCPs, Control Valve positioner, Temp Elements, Proximity level switch, remote mounted electronics, mass flowmeter, ultrasonic flowmeter.

25. Temperature, pressure & flow instruments provided in buried vessel shall be located above ground level. IP 68 shall be provided if instruments are under water.

26. System / Marshalling cabinet size shall be 2100 (H) X 1200 / 800 (W) X 800 (D)

27. All field transmitters shall be dual Compartment Type.

28. Conventional Smart type(HART) Transmitter shall be provided for both open loops & closed loops. Minimum 04 Nos. of hand held communicator (HHT) shall be provided. This shall be loaded with latest HART Software.

29. For Monitoring & Control, separate nozzles / takeoff shall be taken for all cases, for 2oo3 separate tapings shall be used, no branching is allowed ,In case of multi-transmitter installation from a single orifice a separate identical pair of tapping to be provided with a separate transmitter i.e. no branching from a single tapping is allowed.

30. Smart positioner shall be considered for all Control Valves and the same shall be connected to Hart Maintenance system. For high temperature services (Above 200Deg C) remote feedback shall be used for the smart positioner.

31. Valve signature software is required for all Control Valves

32. 4 – 20 mA output from all Gas detectors shall be directly connected to ESD PLC. Electrochemical type Gas detectors to be avoided by the bidders.

33. Separate RACK in ESD PLC to be provided for Gas detection system.

34. For all Local panels rain cover to be provided.

35. For Analysers separate feeders to be directly taken from UPS. No sub-branching allowed at any place.

36. GWR shall be used in pump seal plan; Level switches shall be avoided in lube oil system.

37. All Contacts shall be Gold Plated 2 SPDT.

38. In general separate junction boxes shall be used for the following:
   a) 4-20 mA signals (IS)
   b) 4-20 mA signals (non-IS)
   c) DI/DO 24V (Field switches, push buttons etc.)
   d) Interlock and shutdown signals (Solenoid valves)
   e) Power supply to various instruments.
f) Gas Detectors

g) Vibration signals

39. Separate junction boxes shall be used for signals connected to PLC and to DCS. No signal shall be shared between them in the field junction boxes.

40. Only metal tube Rotameter shall be considered. Glass tube Rotameter shall not be used.

41. SMART Positioner : Metso, Fisher, Dresser or Valve Manufacturers own Make

42. All Instrument Hookups shall be approved by owner/PMC.

43. For boiler drum applications special approval of IBR has to be taken for level instruments

44. Tube metal temp. measurement for boiler drum shall be provided, if applicable, depending upon type of boiler.

Design Basis Philosophy

1.0 Control Philosophy

Note 1: Chemical filters shall be used for air condition system in Control Room.

2. No’s of corrosion monitoring (copper & silver) with temperature and humidity measurement of M/S PURAFIL make must be mounted in rack room of each control room. The location of the monitors must be near the duct and cable entry. The four different AI signals corresponding to above measurements from these two monitors must be connected to DCS with suitable soft alarms.

Suitable Clean Agent System is required for Control Room.

1.1 Type of Control and Monitoring:

a) Centralized Distributed Control System ■ (Note 2)

c) Local Electronic ■ Pneumatic □ (If applicable)

d) Final Control Element Pneumatic ■ (Note-3)

Other___________

Note 2: DCS & PLC hardware shall be suitable for corrosive environment protection coating meeting the Environmental classification class G3 as per ISA-S71.04. Dedicated configuration & diagnostics shall be provided for HART device.

Note-3: Positioner shall be Smart type for all loops except antisurge control loop. Partial stroke testing for ON/OFF valves shall be realized through HART Maintenance system.

Note 4: DCS shall be a DMR system as minimum; all closed & Critical loops shall be connected to redundant I/O channels
### 1.2 Interlock and Shut-down system:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Logic Representation:</td>
<td>As per ISA</td>
<td>Other ________________</td>
</tr>
<tr>
<td>b) Interlock Execution</td>
<td>Independent of Shutdown System</td>
<td>With Shutdown system</td>
</tr>
<tr>
<td></td>
<td>Type of hardware</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DCS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PLC(SIL 3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HART management system for all Analog input signals</td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>c) Shutdown System</td>
<td>Dedicated unit wise</td>
<td>Common for all units</td>
</tr>
<tr>
<td></td>
<td>Type of hardware-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PLC</td>
<td></td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>d) PLC Configuration for shutdown</td>
<td>Dual Processor, Single I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Redundant Processor, Redundant Tested I/O &amp; Redundant Power Supply as a Minimum, with Diode O-ring shall be Provided, individual power supply loading shall not be more than 50% of rated load</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Triple Modular Redundant./QMR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>with 250 milli sec. scan time</td>
<td>(Note-4)</td>
</tr>
</tbody>
</table>

**Note-4:** Only TMR/ QMR PLC to be considered.

d) TUV Classification

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Required</td>
<td>■</td>
<td>Not required</td>
</tr>
<tr>
<td>Class VI</td>
<td>□</td>
<td>SIL-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Note-6</td>
</tr>
</tbody>
</table>

e) Process bypass switch

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Software</td>
<td>PLC console for bypass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hardwired with indication lamp</td>
<td></td>
</tr>
</tbody>
</table>

**Requirement of switches as per P &ID only.**

Maintenance override switch shall be through software with password protection from PLC Console.

g) ESD Switch location

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Local panel</td>
<td></td>
<td>(For Compressors)</td>
</tr>
<tr>
<td>Control room</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Requirement of switches as per P &ID only.
Maintenance override switch shall be through software from PLC

Push Type  □  Pull Type  ■
With protective cover  □  with mushroom head

Note-6: PLC shall be SIL3 as per IEC 61508 & IEC 61511.

h) ESD Button PB - Pull type with Mushroom Head.

1.3 Local Panel Requirement (for Package units)

a) Location  Hazardous Area  ■  Non-hazardous Area  □

b) Type  Weatherproof  ■  Flame-proof (with certified components)  ■
(Push Buttons, Selector Switches, Lamps shall Be ex proof)
    Purged  ■

c) Instruments Type  Pneumatic  □  Electronic  ■

d) Indicating Lamps  PBs  EX-Proof  ■
  Annunciator  (LED)  IS  ■
  Supply  24 V DC  ■

Local panel lamp test logic shall be realized in main PLC.

e) Local indicators  ■  (As per P & ID) Note – 7

Loop powered Indicator shall be IS type

Note – 7: for open loops, repeat indication shall be in series with transmitter, whereas for Closed loop it shall be using single input double output barrier...

2.0 Package Units Philosophy:

2.1 Operating philosophy:

2.2 Logic implementation for package units through Plant PLC
2.3 Anti surge controller

- Conventional Single loop Controller
- DCS
- Dedicated Spl. controller (CCC)
- With serial interface to DCS (Note – 8)

**Anti-surge Control (if any,) shall be dual redundant CCC make, & shall be located in STP (steam Generation Plant) control Room.**

2.3.1 Location of Anti surge Controller

- Control room (on hardwired console)
- SRR
- Local panel (when indicated in P&ID)

2.4 Vibration & Temperature Monitoring

- Bentley Nevada series 3300
- Bentley Nevada series 3500

**VMS/MMS I/O modules shall be within built Barriers. 4-20mA for DCS. MMS to be provided with System-1 monitor. Rule Packs also to be provided. There shall be system-1 monitor enterprise license for STP (steam Generation Plant) with minimum 10 user/client license.**

MMS to be considered as a minimum for Turbine Packages, BFW, ID/FD fan, steam turbine, system etc. shall be connected to independent VMS system; IOs/Controllers/Cards/power supply modules etc shall not be shared. All DOs corresponding to the trip of Machine protection system (Vibration Monitoring Systems) shall be triplicated and connected to ESD on 2oo3 philosophy at ESD. i.e. 3 different DOs cards from BN system must be used. Further all logics corresponding to individual elements (i.e. axial, vibration, temp if applicable) etc shall be implemented in Bentley system but the final DO output must be triplicated at ESD. Also no common trip DO output of two different parameters from MPS is acceptable (for e.g. Axial/Vibration trip clubbed into one DO is not allowed).

2.4.1 Location of monitors

- Control room
- Local panel (In Hardwire Console. Display unit only)

2.5 Location of Speed Governor

- Control room (on hardwired console)
- Local panel (when indicated in P&ID)

2.5.1 Over speeds Trip System

- Pro-Tech GII

2.6 Type of local panel

- Weather proof (Note-11A)
- Purged (for Hazardous Area)
- As per NFPA 496
- Type Z (Note-5)
Note – 8: Dual Redundancy configuration shall be followed.

Note-10: Interlock, shutdown and trip signal shall be hardwired to PLC (Contact signal from machine monitoring). All analog signal from VMS (if any) to DCS shall hardwired. RS485 Communication shall be given as an additional provision. Also Ethernet port shall be provided for connecting the VMS to configuration & diagnostic station (PC based.)

Note –11 Electronics for Governor shall be in Control Room and monitoring shall be from hardwired console only. Redundant or TMR configuration shall be used.

Note-11A with all instruments, items shall be intrinsically safe or flameproof as per clause 1.5. Steam turbine, balance-of-plant equipment, and auxiliary electric equipment.

3.0 DCS Requirements:

GENERAL

The fundamental objective of the various control systems provided for the Thermal Power Project is to facilitate effective plant operations by ensuring the following:-

- Personnel Safety.
- Equipment protection.
- Ease of operation (automation).
- Equipment and cycle efficiency.
- Equipment and system reliability.
- Equipment and system maintainability.

To implement these criteria, normal control and monitoring of the unit shall be from a STP (steam Generation Plant) control Room. The STP (steam Generation Plant) control room shall employ state-of-the-art control system hardware configured for ease of operator interface. From the Control Room, the operators shall be able to start up, load, unload, release for remote dispatch, shut down, and monitor the operation of the associated auxiliary systems. A Distributed Digital Control and Management Information System (DCS) shall be provided as the primary operator interface. Normal operation of the plant is envisaged from monitor and KB. However, it shall be possible to shut the plant to the safe condition (in the event of failure of DCS I/O cards, processors, data highway & MMI).

The principal functions of the DCS are as follows:-

a) Deleted  
b) Provide control steam cycle, steam bypass and water cycle.  
c) Provide control of pulverizes, combustion air, burner ignition, and flame management and Soot Blower.
d) Coal Handling plant, Ash handling plant, CW / ACW system etc. (These will be through Remote Terminal Units

e) Receive input signals that represent the status of process variables and equipment status; condition the signals; and utilize them for control, protection, monitoring, status display, annunciation and SER.

f) Provide the output signals to modulate and control the final devices, such as control valves, control drives, dampers and pumps.

g) 1 No of OPC servers shall be provided for Communication with other systems

h) Deleted

i) Perform information processing functions including logging and printout of historical data, trend displays, elapsed time monitoring, and tantalization of fuel and energy usage and generation.

j) All the control packages of turbo, boiler and their auxiliaries shall be the integral part of DCS.

k) Microprocessor / PLC/Relay based system for individual offsite covering the total functional requirements of modulating control, sequence control, interlocks & protection, monitoring, alarm, data logging, fault analysis, etc. shall be supplied by bidder.

The design of the control system and related equipment shall adhere to the principle of “fail safe” operation at all system levels and provide reliable and efficient operation of the plant under dynamic conditions and attainment of maximum station availability.

Suitable gateways / soft links / protocols and time synchronization facility including all required software & hardware shall be provided for all microprocessor / PLC-based system for interfacing with DCS. Master / Slave clock system shall be supplied by bidder for time synchronization of DCS and microprocessor based system / PLC

l) Status of all drives, pumps, tanks, etc should also be available in central control room.

m) All HT motor bearings shall have duplex RTDs for remote indication and local temperature gauges for local indication.

3.00.01.01 Multi tasking of Processors

The distributed digital control system is required to address the following tasks:-

1) Open loop control (binary)
2) Closed loop control (analog modulating)
3) Plant monitoring/signal acquisition and processing

The microprocessor based system has the capability to perform the above tasks either separately or in a combined form. As multi-function processors have a number of control functions and are preferred to be in completely redundant mode, security of control functions including those of protection would be maintained even with the loss of the active processor as well as the functions could be taken over by standby processor.

3.00.01.02 Signal Acquisition and Processing Modules for Monitoring & Control Functions

Primary instruments for monitoring functions shall be provided separate from those for control tasks. Keeping this segregation of field instruments, the system philosophy could adopt separate processors for monitoring tasks.
Monitoring task being less critical compared to control tasks, the processors for monitoring could be non-redundant. Alternatively, as the hardware for monitoring functions is generally similar/identical to those for the control tasks, it is possible to combine the monitoring portions with control tasks. All processors/cards/power supply etc for closed loop shall be redundant.

3.00.01.03 Processor Task Allocations

The system shall perform overall control tasks having appropriate redundancy built in for all the system functions both at processor and peripheral level. No failure of any single peripheral or processor leads to any system function or data being lost.

For the system with multi-function processors, functional distribution is adopted and geographically, the system can be centralized.

Each functional group consists of dedicated microprocessors including redundancy and dedicated input and output processing. The redundant multifunctional processors are in a hot back up mode with bump less transfer. Following tentative segregation for regulating controls is proposed, however final segregation shall be subject to Owner’s approval during detailed engineering:-

a) Coordinated master controls and Fuel feed control  
b) Air flow and excess air correction  
c) Furnace draft  
d) Mill related controls  
e) Lime control  
f) Feed water/drum level  
g) Deaerator, hotwell  
h) SH steam temperature control (multi variable control)  
i) RH steam temperature control (multi variable control)  
j) HP/LP heaters  
k) Deleted  
l) BMS (TMR/QMR) control. Also the cards and Processor for BMS shall be fail safe type minimum SIL-3 approved.

Segregation further depends upon I/O handling capacity of the processor.

Other loops of the plant e.g. miscellaneous loops can be distributed amongst the above processors.

Each group has sufficient spare capacity of at least 20% to meet modification/extension of the system. Multi-function processors can incorporate the corresponding interlocks (open loop control tasks of the system).
Interlock and modulating controls are to be so assigned to the processors in such a way that failure of any processor does not lead to shut down of the entire unit. In no case CPU loading should exceed 50% of its capacity. Bidder to submit calculation of CPU loading along with his bid.

3.1 Functional Requirements:

Control and Data Acquisition System
Data Logging and Report Generation
Management Reports (limited)
Advanced Control
Plant Optimization
Offsite Automation
Data Storage and Archival
Management Information System reporting
Advance Diagnostics

3.2 Operator Consoles:

All servers, Engineering stations etc shall be in RAID 5 configuration all other (OS/PC) shall be in Raid -1 configuration with min 2TB HDD, 16 GB RAM, with latest windows & anti-virus support at least for 5 years For Client Server Architecture 1:1 Server Shall be redundant (RAID 5)

Network securities shall be provided by the bidders in all control rooms as per IEC 62443 for protection of the system from both internal and external threat. The requirement includes all USB port blocking (including all monitors /CPU), provision of sufficient firewalls, antivirus updation for one year, patch updation, unauthorized logging recording with events etc. must be addressed by the bidder. In case of Server-Client based DCS systems, all operator stations shall be direct connect type (they should not depend on Servers for data). No System Servers shall be used as Operator stations

A. SUPER HEATED HP STEAM GENERATION UNIT/BMS

DCS

3 Nos Operator Stations with, 22” TFT touch screen colour LED type dual monitors (stacked)
1 No. Engineering Station with, 22” TFT touch screen colour LED type

1 no. of Membrane Operator’s Keyboard and 1 no. of QWERTY engineer’s key boards with mouse with each operator station with touch screen, mouse

1 Nos ES/OS dual personality, 22” TFT touch screen colour LED type dual monitors

1 No. Supervisor station

System shall be supplied with equitable tags Licenses shall be for Life Time.
Whole plant data shall be made available in all OS and ES.
BMS

BMS PLC (separate PLC for each Steam Generation Unit)

1 Nos ES/OS dual personality with SOE, 22” TFT touch screen colour LED type dual monitors type for each BMS

1 No. Engineering Station with, 22” TFT touch screen colour LED type (common for all BMS)

1 No. Annunciator with LED lamps with split type architecture for each BMS

1 No Auxiliary Console for each BMS

1 No of engineering station machine Monitoring System for all other facilities such as BFW pumps etc.

1 No of Engineering Station for Wood Ward governor System if any

1 No. Annunciator with LED lamps with split type architecture

2 Nos A3 Heavy duty Colour HP makes Laser printer

System shall be supplied with equitable tags. Licenses shall be for Life Time.

All ES (DCS/BMS) shall be housed in separate Engineering Room in Control Room.

It shall have latest Bentley Nevada Vibration Monitoring system. Suitable speed-monitoring Woodward make and Potech GII or better over-speed trip system shall be provided.

VMS system shall be connected in dual redundant mode to MMS System-1

COMMON FACILITY

1 No of AIMS (alarm information management system)

1 No History Node and Alarm Management PC with long term history license & 1 Year data storage, 22” TFT, COLOR, LED type

1 No. Instrument Asset Management System (IAMS)

1 No OPC server with 22” TFT Color LED monitor with requisite software/hardware for Remote Viewing common for all Steam generation units,

One OPC server shall be provided with DCS/PLC system with OPC connectivity to ERP/MIS system/data exchange. Vendor shall also provide necessary software/hardware (OPC server & software) and manpower support / assistance for establishing connectivity of the other systems system with ERP & other systems.

OPC server tag license must be for minimum 10000 tags, PC server design for Steam Generation Plant will be based on no of STP (steam Generation Plant) related tags only.

1 No. Documentation Node 22” TFT, COLOR, LED type

1 No. Terminal Server, 22” TFT, COLOR, LED type (if required)

1 No. Fire wall minimum
1 No of MMS System-1 Server
1 No of MMS System-1 Client
1 No. Master station for CCTV
1 No. 55” Large Video Screen
1 No Engineering station for F&G PLC

B. ANALYZER PLC
One Analyzer PLC for each Analyzer shelter shall be provided with redundant connectivity to Steam generation control system.

- 1 No of Engineering station shall be provided for Analyzer PLC (common)

C. FOLLOWING SHALL BE PROVIDED AS COMMON FACILITY FOR THE STEAM GENERATION UNITS

b) Console configuration
   - Single
   - Stacked (Dual)

c) Type of monitor
   - CRT
   - LCD/ TFT 22"

d) Open system connectivity
   - Yes (through OPC)
   - No

e) Assignable Recorders on each console
   - Yes
   - No

Historic Trending for all points shall be provided.

f) Engineering functions from operator console
   - Yes
   - No

g) Historic Trending on each console
   - For all points
   - Recording points only

h) Auto tuning facility
   - Required
   - (Note – E)

Note- E Auto tuning as per vendor standard shall be provided.

3.3 Engineering Consoles: Required
3.4 Type of Reports Required Hourly

Alarm History
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift wise</td>
<td>Alarm Summary</td>
<td>Daily</td>
<td>MIS reports</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5 Type of Controller</td>
<td>Multi-loop</td>
<td></td>
<td>Single-loop</td>
</tr>
<tr>
<td>3.6 Historical database</td>
<td>Unit wise</td>
<td>Combined</td>
<td>(Refer blocks as per 3.2a) Other</td>
</tr>
<tr>
<td>3.7 Plant History</td>
<td>Required</td>
<td></td>
<td>Not Required</td>
</tr>
<tr>
<td>3.8 Alarm Management System</td>
<td>Required</td>
<td></td>
<td>Not Required</td>
</tr>
<tr>
<td>3.9 Giant Screen</td>
<td>Required</td>
<td></td>
<td>Not Required</td>
</tr>
<tr>
<td>3.10 Sequence of Event recording</td>
<td>Required</td>
<td>Not required</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In DCS</td>
<td>In separate unit</td>
<td></td>
</tr>
</tbody>
</table>

Note-12: SOE shall be part of PLC with time stamping of events of 1 milli sec resolution as an inbuilt feature of PLC

### 3.11 Field Multiplexer
- Required
- Not required
- i) 4 ~ 20 mA open loops
- ii) Thermocouple (open loops)
- iii) RTD (open loops)
- iv) Contact inputs (open loops)

### 3.12 Foreign Device Interface with DCS required for: (Note – F)
- Programmable Logic Controllers
- Analyzer system
- Chromatographs
- Tank Gauging System
- Supervisory Computer
- Package PLCs
- Anti Surge Controller
- Vibration & Temperature Monitoring System
- Gas Detection System
- Alarm Management System
- Giant Screen
- Governor
- UPS
- Corrosion Monitors

Note – F Foreign device interface shall be Redundant with dual communication to DCS.

### 3.13 Advanced Control Function Requirements-
- Through DCS
- Through Dedicated

NOT APPLICABLE
### Supervisory Computer

3.14 Maintenance Information System
- Required: Not required
- Dedicated: with DCS

3.15 Training Kit
- Required: Not required

3.16 Training Simulator
- Required: Not required
- Process model required for

3.17 Redundancy Philosophy:

<table>
<thead>
<tr>
<th>Component</th>
<th>Required</th>
<th>1:1 redundancy</th>
<th>Not required</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Controller and Data Acquisition system</td>
<td></td>
<td>1:1 redundancy</td>
<td></td>
</tr>
<tr>
<td>Controller</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Acquisition System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Communication Sub-system</td>
<td></td>
<td>1:1 redundancy</td>
<td></td>
</tr>
<tr>
<td>c) History</td>
<td></td>
<td>1:1 redundancy</td>
<td></td>
</tr>
<tr>
<td>d) Power supplies Sub-system</td>
<td></td>
<td>1:1 redundancy</td>
<td></td>
</tr>
<tr>
<td>e) I/O communication modules</td>
<td></td>
<td>1:1 redundancy</td>
<td></td>
</tr>
<tr>
<td>with CPU (I/O bus between CPU and I/O with all necessary hardware)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f) Main data highway</td>
<td></td>
<td>1:1 redundancy</td>
<td></td>
</tr>
<tr>
<td>g) Communication Cards</td>
<td></td>
<td>1:1 redundancy</td>
<td></td>
</tr>
<tr>
<td>h) Power supply (Power supply for all CPUs, I/O power supply modules)</td>
<td></td>
<td>1:1 redundancy</td>
<td></td>
</tr>
</tbody>
</table>

Redundant Bulk Power supply with diode arrangements shall be provided for field instruments. Individual power supply Loading 50% only, All BPS Failures shall be connected to DCS as a separate DI signal with clear software alarm description. Make: Quint/ Cosel/ Stahl/ Weidmuller/Wago may also be considered. All Diode O rings failures shall be connected to DCS as a separate DI signal with clear software alarm description. All BPS/Diode O ring must have LED indications for indicating their healthiness locally. All the MCC and Instrument interface (For all
DI/DO/AI/AO signals) shall be connected through a separate shielded cable of 1.5 sq mm and not through control cable.

i) Serial (RS-485) Modbus Redundant 1:1 redundancy
(For Interlock PLC)

3.18 Loading philosophy

Control Processor 50%
Communication Processor 50%
Communication Bus 50%
(Note-13)

Each Controller loading shall not exceed more than 50% (hardware and software load of each controller) in any case, after implementation of complete project and running at peak load. In case more controllers are required to meet 50% loading criteria, CONTRACTOR to include additional controllers without any cost implication.

Note-13: The maximum number of nodes in the network shall not exceed 60% of the maximum capacity.

3.19 Scanning Time

50 msec. for anti surge control loops
200 msec. for flow and pressure control loops.
500 msec. for all other control loops
5 sec. for temperature acquisition loops
1 sec. for all other acquisition loops

4.0 Control panel / Hard-wired console Instrumentation:

4.1 Type of control panel

Graphic Closed back
Non-Graphic Open back
Semi-Graphic Console type

4.2 For Control Room Instrumentation (As per P&ID) (Note-14)

a) Indicators, Integrators, All Critical
Indicating controllers, etc. (As per P&ID)
None

All rights reserved
### Instrumentation

<table>
<thead>
<tr>
<th>Location</th>
<th>Panel</th>
<th>Console (As per P&amp;ID)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti Surge Controller</td>
<td>6” x 3”</td>
<td>OEM standard</td>
</tr>
<tr>
<td>Speed Governor</td>
<td>6” x 3”</td>
<td>OEM standard</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b) Recorders</th>
<th>All</th>
<th>Critical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Panel</td>
<td>Console</td>
</tr>
</tbody>
</table>

**Size:**

<table>
<thead>
<tr>
<th>Assignable Trend Recorder</th>
<th>6” x 3”</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>c) Multipoint Temperature Critical Parameters Recorders</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Panel</td>
</tr>
<tr>
<td>Size:</td>
<td>Large case</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>d) Alarm Annunciation</th>
<th>All</th>
<th>Critical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Panel</td>
<td>Console</td>
</tr>
<tr>
<td>On console as per P&amp;ID</td>
<td>Hanging Type</td>
<td></td>
</tr>
<tr>
<td>First out sequence</td>
<td>Required</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>e) Multi-point Temperature Indicator</th>
<th>Required</th>
<th>Not required</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>f) Auto Manual Station</th>
<th>On Panel</th>
<th>On Console</th>
<th>(Note-15)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>g) Manual Loading Station</th>
<th>On Panel</th>
<th>On Console</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>h) Selector Switch</th>
<th>On Panel</th>
<th>On Console (As per P&amp;ID)(Note-15)</th>
</tr>
</thead>
</table>

|-------------------------------------|----------|---------------------------------------|

<table>
<thead>
<tr>
<th>j) Process Bypass Switch/ Indication (As per P&amp;ID)</th>
<th>On Panel</th>
<th>on Console (PLC Console) (Note-15)</th>
</tr>
</thead>
</table>

**Note-14:** Location shall be as per P&ID/ licensor requirement.
Note-15: Dedicated HWC console shall be provided for PLC interlock, shutdown, manual operation like bypass, start, and stop commands, etc. Hardwired console shall be Mosaic tiles type. Placement of Hardwired Console shall be adjacent to its dedicated operator Station console for ease of operation.

Note-16: Hardwired only for emergency and critical trips as per P&ID.

Note – G The first out sequence shall be F3A for control panel mounted alarm annunciator and auto reset type for control room mounted alarm enunciator

k) Start up / shut down operation from control room:
   i) Rotating Equipment As per P&ID
   ii) Shut down valves As per P&ID
       with partial stroke system
   iii) Dampers & gates As per P&ID

l) Status lamps in control room:
   i) Rotating Equipment As per P&ID
   ii) Shut down valves As per P&ID
   iii) Dampers & gates As per P&ID
   iv) Flame Scanners As per P&ID

5.0 General:

5.1 Type of Power Supply:

<table>
<thead>
<tr>
<th>Type</th>
<th>Tolerance</th>
<th>Duration after Mains Failure</th>
<th>Emergency Power Supply Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>110 V AC UPS</td>
<td>115V± 10% 50Hz ± 3%</td>
<td>60 minutes</td>
<td>Required</td>
</tr>
<tr>
<td>24 V DC</td>
<td>24VDC± 1V</td>
<td>30 minutes</td>
<td>Required</td>
</tr>
</tbody>
</table>

5.2 Power Supply Requirement (Note-18)

<table>
<thead>
<tr>
<th>115V AC 50Hz.UPS</th>
<th>110V DC</th>
<th>24V DC</th>
<th>110 V AC Non UPS</th>
<th>230 VAC 50Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributed Digital Control system</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td>Supervisory Computer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td>Package Units</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d)</td>
<td>Alarm Annunciator Annunciator shall be LED Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e)</td>
<td>PLC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f)</td>
<td>Solenoid Valves</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g)</td>
<td>Smart, I/P, Transmitters Voltage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h)</td>
<td>I/P Interrogation Voltage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>Gas Detection System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j)</td>
<td>Analyzers and Analyzer System for Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>k)</td>
<td>Analyzers and Analyzer System for Monitoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>k)</td>
<td>Chromatographs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l)</td>
<td>Training Kit for DCS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>m)</td>
<td>Training Simulator for DCS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n)</td>
<td>Level Gauge Illumination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o)</td>
<td>Cabinets Lighting Control Room Local Panel (If applicable)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p)</td>
<td>Local Panel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>q)</td>
<td>CCTV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r)</td>
<td>Analyzer Shelter Air Conditioning</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Note-18: 24 VDC wherever required, Shall be provided with redundant bulk power supply unit.

5.3 Power supply distribution:

a) Local Panel
   UPS Distribution Board
   Control Room Distribution Cabinet

b) Analyzer Shelter
   UPS Distribution Board
   Control Room Distribution Cabinet
   SRR Distribution Cabinet

c) Instruments & Analyzer
   UPS Distribution Board
   Control Room Distribution Cabinet

The failure signals of all UPS should be connected to DCS as a separate DI contact.

5.4 Cable Entry to:

a) Control Rooms
   MCT Blocks
   Pipe Sleeves

b) Satellite Rack Rooms
   MCT Blocks
   Pipe Sleeves

c) Local control Rooms
   MCT Blocks
   Pipe Sleeves

d) Analyser Rooms / Houses
   MCT Blocks
   Pipe Sleeves

5.5 Air Supply at Battery Limit

| Operating pressure | Minimum: 4.0 kg/cm²g | Normal: 5.5 kg/cm²g | Maximum: 6.0 kg/cm²g |

5.6 Size of Instrument Nozzles shall be as per following

<table>
<thead>
<tr>
<th>Instrument Type</th>
<th>Process / Vessel Connection</th>
<th>Instrumentation Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP Flow Instruments</td>
<td>½&quot; NPT (M)</td>
<td>½&quot; NPT</td>
</tr>
<tr>
<td>External Displacer on Vessel</td>
<td>2&quot; Flanged</td>
<td>2&quot; Flanged</td>
</tr>
<tr>
<td>( Min. Rating ANSI 300#)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrumentation Type</td>
<td>Min. Rating ANSI</td>
<td>Connection Type</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Internal Displacer</td>
<td>300#</td>
<td>4&quot; Flanged</td>
</tr>
<tr>
<td>External Ball Float on Vessel</td>
<td>300#</td>
<td>2&quot; Flanged</td>
</tr>
<tr>
<td>Internal Ball Float</td>
<td>300#</td>
<td>4&quot; Flanged</td>
</tr>
<tr>
<td>Magnetic Level Gauge</td>
<td>300#</td>
<td>2&quot; Flanged</td>
</tr>
<tr>
<td>D/P Level</td>
<td>300#</td>
<td>½ NPT (M)</td>
</tr>
<tr>
<td>D/P Level with Remote Seal Diaphragm</td>
<td>300#</td>
<td>2&quot; Flanged</td>
</tr>
<tr>
<td>D/P Level Direct Vessel Mounted</td>
<td>300#</td>
<td>2&quot; Flanged</td>
</tr>
<tr>
<td>RADAR – Direct Mount on vessel</td>
<td>300#</td>
<td>3&quot; flanged</td>
</tr>
<tr>
<td>GW RADAR – Side/Side Chamber Mounted on vessel</td>
<td>300#</td>
<td>2&quot; flanged</td>
</tr>
<tr>
<td>Internal GWR on Equipment</td>
<td>300#</td>
<td>4&quot; Flanged</td>
</tr>
<tr>
<td>Special Level Instrument on Equipment</td>
<td>300#</td>
<td>2&quot; flanged</td>
</tr>
<tr>
<td>Tank Level Instruments (Servo) on Atmospheric tank / Pressurized Equipment</td>
<td></td>
<td>6&quot; flanged</td>
</tr>
<tr>
<td>Tank Level Instruments (Radar) on Atmospheric tank clean service / Pressurized Equipment</td>
<td></td>
<td>8&quot; flanged</td>
</tr>
<tr>
<td>Tank Level Instruments (Radar) on Atmospheric tank viscous service / Pressurized Equipment</td>
<td></td>
<td>24&quot; flanged</td>
</tr>
<tr>
<td>Tank Level Instruments (Capacitance/Ultrasound/R.F.Probe) on Atmospheric tank / Pressurized Equipment</td>
<td></td>
<td>2&quot; flanged</td>
</tr>
<tr>
<td>Pressure Instruments</td>
<td>300#</td>
<td>½ NPT (M)</td>
</tr>
<tr>
<td>Press.Gauge</td>
<td>300#</td>
<td>½ NPT (M)</td>
</tr>
<tr>
<td>Pressure Instruments on Vessel</td>
<td>300#</td>
<td>3&quot; Flanged</td>
</tr>
<tr>
<td>Pressure Instruments on Standpipe</td>
<td>300#</td>
<td>1 ½&quot; Flanged</td>
</tr>
<tr>
<td>Chemical Seal pressure Instrument gauge on Vessel</td>
<td>300#</td>
<td>1 ½&quot; Flanged</td>
</tr>
<tr>
<td>Diaphragm Seal pressure Instrument gauge on Vessel</td>
<td>300#</td>
<td>1.5&quot; Flanged</td>
</tr>
</tbody>
</table>
Note:-

a. There shall be a separate tapping for each of the instruments on any pipeline/vessel. No multiple instruments from one tapping is acceptable (for example PG and PT from single pipe line tapping with single or double mechanical isolation valves are not acceptable). In case of multi-transmitter installation from a single orifice, a separate identical pair of tapping to be provided with a separate transmitter i.e. no branching from a single tapping is allowed.

b. All type of instrument tapping flange rating shall be minimum ANSI 300#, irrespective of minimum design pressure. However for pressure rating of 600# class and above, RTJ flange shall be used. At few locations, double isolation valves shall be used as per table given below.

<table>
<thead>
<tr>
<th>Installation</th>
<th>Pressure tappings</th>
<th>Level tappings</th>
<th>Flow elements</th>
<th>Control valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 #</td>
<td>SINGLE</td>
<td>SINGLE</td>
<td>SINGLE</td>
<td>SINGLE</td>
</tr>
<tr>
<td>600 #</td>
<td>DOUBLE</td>
<td>SINGLE</td>
<td>DOUBLE</td>
<td>SINGLE</td>
</tr>
<tr>
<td>900 # / 1500 # / 2500 #</td>
<td>DOUBLE</td>
<td>DOUBLE</td>
<td>DOUBLE</td>
<td>SINGLE</td>
</tr>
</tbody>
</table>

5.7 Type of taps for Orifice

- Flange (<= 12")
- Corner (for 1½")
- 2 ½ -8D (For > 12")
- D-D/2 (for > 12")

(Unless otherwise recommended by process licensor)

5.8 Installation / Tubing hook-ups:

a) Instrument Installation

- Close coupled (For all flow instrumentation) (Note- H)
- Remote (for level, Pressure & PDT- Piping & tubing Standard)

b) Instrument impulse lines

- Tubing (for utilities)
- Piping
- Any other _____________

(Note-20) with piping & tubing connection at inst. end only up to 600#. For high pressure only piping shall be followed..
### c) Instrument valve manifolds

- **i) For pressure gauges**  
  - Integral: □  
  - Fabricated: ■ (Note – I)

- **ii) For flow DP transmitter**  
  - Integral: ■  
  - Fabricated: □

- **iii) For Others**  
  - Integral: □  
  - Fabricated: ■

- **iv) For PI**  
  - Integral: ■  
  - Fabricated: □

*Note – I For pump discharge pressure, pressure gauges shall be mounted in a separate stanchion.*

### d) Impulse Line valves (After first isolation valve provided by piping)

| Isolation valves | Gate | ■ | Globe | □ | (All instrument Valves except equalizing valve must be gate type) |
|------------------|------|---|-------|---|
| Vent/drain valves | Gate | □ | Globe | ■ |

### e) Signal and Air supply tubing

- **SS tubing**: ■  
- **PVC covered Copper tubing**: □  

<table>
<thead>
<tr>
<th>Tube size</th>
<th>6 mm OD</th>
<th>■</th>
<th>¼” OD</th>
<th>□</th>
</tr>
</thead>
</table>

### f) Steam Tracing

- **SS tubing**: ■  
- **3/8” OD**: □

<table>
<thead>
<tr>
<th>Tube size</th>
<th>6 mm OD</th>
<th>□</th>
<th>3/8” OD</th>
<th>■</th>
</tr>
</thead>
</table>

### g) Seal pot required for Steam / condensing Vapor instruments

- **Yes**: □  
- **No**: ■  

*Note – J For steam level instruments, seal pot will be used.*

### h) Main instrument air header and Branch header

- **CS**: □  
- **SS**: ■

Main instrument air header shall be at least 2” (SS) minimum depending on requirement. It shall have 1” minimum takeoff (SS) with Gate type isolation valve (SS) & further distribution for each instrument through separate ½” SS line with ½” SS Ball valve single piece design with SS handle & with 6 mm OD SS316 tubing.
i) Inst. Air isolation valve for each instrument.
   Brass ☐ SS ☐

j) Impulse tubing 1/2" OD ☐

5.9 Field Transmitter Type:

a) Open loops Conventional ☐ Smart ☐ Fieldbus ☐

b) Close loops Conventional ☐ Smart ☐ Fieldbus ☐

c) For anti-surge loops Conventional ☐ Fieldbus ☐

d) For shut-down loops/ Safety system loops Conventional ☐ Smart ☐ Fieldbus ☐

Transmitters shall be of 10 years stability

5.10 Deleted

5.11 Field positioner type

Pneumatic ☐ Electropneumatic ☐ Smart ☐ Fieldbus ☐

Partial stoke testing shall be provided for ESD valves.

For ESD valves, Proximity type switches shall be provided for open & close status in addition to Smart positioner.

5.12 Signal type:

a) For Smart transmitters 4-20 mA DC with superimposed Digital Engineering Data (HART) ☐

LCD display in Engineering Unit and % for level in field ☐

LCD display for smart transmitter shall be in line with 5.20

b) Fieldbus Foundation Fieldbus ☐ Profibus PA ☐

c) Pneumatic Signal 0.2-1 kg/cm²g ☐

5.13 Output meter
5.14 Process Instrument Type for shut-down

a) For pressure
   - Process switch
   - Transmitter

b) For Level
   - Process switch
   - Transmitter

c) For flow, temperature
   - Process switch
   - Transmitter

d) For package units including Pump seal
   - Vendor Standard
   - Transmitter

e) Any other
   - As per Licensor’s Requirement

5.15 Hazardous Area Protection: (Note-23)

a) Field transmitters intrinsically safe
   - Flame proof

b) Field switches intrinsically safe
   (For antisurge loops shall be exproof)
   - Flame proof

c) I/P converters intrinsically safe
   (Proximity type LS)
   (Note-24)
   - Flame proof

d) Solenoid valves intrinsically safe
   (where applicable)
   - Flame proof

e) Positioners Intrinsically safe
   - Flame proof

f) Special instruments/ intrinsically safe
   - Flame proof
   - As per manufacturer standard

   Local Panel elements shall be exproof.

Analysers shall be exproof only.

Note-23: If intrinsically safe item is not available for any instruments, then it must be Flame proof Exd. MCC I/Os shall be non-intrinsically safe. The shutdown/interlock inputs to PLC shall be intrinsically safe.

Note-24: Limit switches shall be intrinsically safe.

5.16 Intrinsic safety Barriers

- Required
  - Isolating type

- Not required
  - (If required)

Line monitoring for O/P barriers

- Not required
  - Required

Line monitoring for AO barrier is required.
5.17 Analyzer/GC Installation

5.18 Earthing system:

a) Panels, racks, cabinets, consoles, shelters etc. and all Junction boxes with power more than 110 V (Note-25)

b) Signal earth

Separate signal earthing pit (Note-25)

c) Barrier earth

Separate safety earthing pit (Only for Zener barriers)

For VMS, Governor & Antisurge Controller (if applicable) earthing shall be as per vendor recommendation

Note-25: DCS/PLC console/panel earthing as per DCS vendor recommendation.

5.19 Type of cables:

Flame retardant
Flame retardant and low smoke
Flame retardant and Fire resistant (Note-27)
(Wherever specifically indicated)

Note-27: For cabling to fire-proof valves.

6.0 Other Instrumentation and Systems:

6.1 Flow instruments:
As per Licensor’s requirement
### Instrumentation

#### a) General Service
- For 2” lines and above: Orifice plate
- Other

- For 1½” lines and below:
  - Variable Area meter
  - Meter Run
  - Integral Orifice
  - Other as per licensor

#### b) For Air flow
- Venturi / Ultrasonic flow
- Other

> Airflow measurement shall be Venturi / Ultrasonic type. Pitot tube is not acceptable for airflow measurement.

#### c) For Cooling water
- Mag.flow
- Ultrasonic flow
- Other

> Magnetic flow meter in line mounted shall be used.

#### b) For highly viscous and fouling service, high temperature service.
- Mass Flow
  - (Coriolis type)
- PD meter
- Wedge
- Orifice
- Target
- Other

#### e) Custody and Product Metering

- **i) Liquids**
  - PD meter
  - Turbine
  - Mass / Ultrasonic(5-path)

- **ii) Gas**
  - Orifice
  - Turbine
  - Any Other (As per P&ID)

- **f) Performance Metering**
  - Orifice
  - Mass
  - Turbine
  - PD Meter
  - Any Other (As per P&ID)

- **g) High Rangeability Applications**
  - Turbine
  - Vortex
  - Mass
  - Others

- **h) Flare Flow Measurements**
  - Ultrasonic type
  - Other

- **i) Other** (as per P&ID)

- **j) FD fan air flow** (as per P&ID)

#### 6.2 Temperature Measurement:
### Instrumentation

#### 6.1 Temperature Measurement

<table>
<thead>
<tr>
<th>Item</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Temperature gauges</td>
<td>Bimetallic Filled system</td>
</tr>
<tr>
<td>b) Thermocouple</td>
<td>Grounded Un-grounded Normally ‘K’ type</td>
</tr>
</tbody>
</table>

**Thermocouple shall be duplex type.**

<table>
<thead>
<tr>
<th>Item</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Transmitter</td>
<td>Required Not-required For all Only for control and Shut down</td>
</tr>
<tr>
<td>Transmitter Location</td>
<td>Control-room Field Head-mounted Remote-mounted</td>
</tr>
</tbody>
</table>

**Temp transmitter shall be used for both open loops & Closed loops. Transmitter shall be dual compartment type.**

<table>
<thead>
<tr>
<th>Item</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>c) Thermowell flange rating</td>
<td>As per piping specifications/ Vessel Nozzle rating Minimum 300# rating Other As per licensor’s requirement / As Piping clause</td>
</tr>
<tr>
<td>d) RTD (when used)</td>
<td>PT-100, 3 Wire, calibration as per IEC 60751 (For machine parameters)</td>
</tr>
</tbody>
</table>

#### 6.3 Level Measurement:

<table>
<thead>
<tr>
<th>Item</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) In General – 3” remote seal DP Capillary Type</td>
<td>External Displacer- for all interface level. Process radar – guided wave radar Ultrasonic - level measurement for buried vessels/ CBD/Sump.</td>
</tr>
<tr>
<td>b) Level Stand-pipe philosophy</td>
<td>Licensor Requirement</td>
</tr>
<tr>
<td>c) Tank Level Gauging</td>
<td>Black Oil Radar White Oil Radar LPG Radar Multi point temperature required.</td>
</tr>
</tbody>
</table>

**Tank Farm Management System.**

<table>
<thead>
<tr>
<th>Item</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank Farm Management</td>
<td>Dedicated with comm. to DCS With DCS</td>
</tr>
<tr>
<td>Redundancy</td>
<td>Required Not required</td>
</tr>
</tbody>
</table>
No. of display screens  Two □ Three □ Any Other (work station with TFMS software) □
Display Location Control room □ Satellite room □ Any Other □

e) Special Level Instrumentation (If required): (As per P&ID)

RF Type for
Silos □ Crude Desalters □ Any other □
Capacitance Type □
Ultrasonic Type □
Any Other □

f) Level measurement for buried vessel shall be Radar type only. For pump seal plan level instruments, guided wave radar shall be used.

6.4 Air Filter Regulator Filter Size 5 micron Max. □

6.5 Desuperheater Separate Water control valve □

6.6 Test /Lab equipment Required □ Not Required □
As per client’s requirement

6.7 CCTV System IP based with 14 No Cameras.

a) CCTV Required □ Not required □
For Process units (PTZ) □
Flare (Thermal detector) □
Plant surveillance □
Any other (Utilities & off sites) □

b) Monitor Location

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of Monitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Room</td>
<td>Minimum 01 with 55&quot;FHD monitor</td>
</tr>
</tbody>
</table>


c) Recording facility Required □ Not required □
All cameras □ Selective □
Number of points (If selective) □
6.8 Fire and Gas Detection (F & G) System:

a) F&G System Required ☐ Not required ☐

b) Gas detection system Required ☐ Not required ☐

(Note-30) Dedicated Gas Detection system shall be provided. 4 – 20 mA output from Gas detector shall be directly connected to Separate Rack of DCS or ESD PLC.

i) HC, H2 Detectors Catalytic diffusion ☐ Only for H2
    IR Type ☐ for HC
    Any other ______

Output 4-20 mA ☐ Vendor standard ☐

Other ______

ii) H2S Detectors Electrochemical ☐ Semiconductor ☐
    Any other ______
    4-20 mA ☐ Vendor standard ☐

Other ______

iii) Toxic gas detector As per P&ID

iv) Other gas detectors As per process package ☐

d) Fire detection system

i) Automatic fire detection Required ☐ Not required ☐
    If yes, any specific areas to be covered_________

ii) Plant / Non plant building

Fire detection Required ☐ Not required ☐

d) Separate F & G LAN Required ☐ Not required ☐

d) Type of F&G PL:F& G system PLC shall be SIL 3 certified, same make as that of ESD system of Steam generation unit.

6.9 Integrated Machine Monitoring System:

Required ☐ Not required ☐

For monitoring ☐

For predictive maintenance ☐
- Each BMS allied network shall have independent MMS system, No electronics shall be shared

6.10 Boiler drum Instrumentation

<table>
<thead>
<tr>
<th>Type of level instrument</th>
<th>Conductivity</th>
<th>DP</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety valves</td>
<td>Section I</td>
<td>IBR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level measurement</td>
<td>2 out of 3</td>
<td>other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Any other __________

All trips shall be based on 2oo3 logic only. In steam drum measurement, additionally one GWR suitable for boiler application shall be provided.

6.11 Ambient air monitoring system (check)

<table>
<thead>
<tr>
<th>No. of fixed stations</th>
<th>Required</th>
<th>Not required</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of mobile stations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mobile van Required

Meteorological Sensors Required

6.12 Stack Monitoring System:

<table>
<thead>
<tr>
<th>Required</th>
<th>Not required</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Separate for each stack

Common for all stacks

Common central data storage unit (Note-31) Required

Measuring techniques & response time shall be indicated. Separate Sample Handling system for each analyzer.

Note-31: CDSU shall be provided.

6.13 Safety valve testing at site before installation:

<table>
<thead>
<tr>
<th>At Site</th>
<th>Testing jig</th>
</tr>
</thead>
<tbody>
<tr>
<td>By Client/PMC</td>
<td>Required</td>
</tr>
<tr>
<td>By Contractor</td>
<td>Not required</td>
</tr>
</tbody>
</table>

(Note-32)

Note-32: Test Bench, Testing jig, Testing medium shall be provided by LSTK contractor with valid Pressure testing certificate for entire duration of testing as per Statutory regulations and following all Safety norms.

6.14 Deleted
6.15 Fire proofing of Instrument cable ducts

- Required: ☐
- Not required: ☒

Fire proofing of Instrument cable trays

- Required: ☐
- Not required: ☒

6.16 Flow Element sizing

- Orifice, Ventury: As per ISO 5167 (otherwise as per P&ID)

6.17 IAMS for DCS HART shall be included in the DCS /PLC package.

6.18 For DCS, HART Compatible AI & AO modules shall be provided

6.19 INSTRUMENT SIZING CALCULATION in Intools

All the sizing calculations of Control Valve, Safety Valve & flow element (orifice plate / venture / flow nozzle etc) shall be done using Intools (Smart Plant instrumentation Latest Version). The related dB file of the sizing data and calculation to be provided to PMC/OWNER for checking. LSTK to provide fully functional licensed Intools (SPI) software along with other necessary software (like Oracle etc) to Owner before sizing data is provided to the owner. Training on Intools to be provided from OEM.

6.20 DOCUMENTATION NODE

For documentation node the software to be used shall be PRODOK only. Training in use of the software from OEM.

Spare Philosophy:

a) Mandatory spares: Refer mandatory Spare Section

b) Spare Parts

- For two years operation ☐
- For Startup and Commissioning (As required) ☒
- Consumable spares for six months operation ☒

c) DCS, PLC, Gas Detection, CCTV, Machine Monitoring Spare Philosophy:

- System Spares (Control Room wise)
  - Bus Capacity: 40%
  - Number of Nodes: 30%

- Installed Spares
  - I/O Level: 20%
  - Marshalling: 20%

- Spare Space
  - I/O Level: 20%
  - Processor: 40%
  - Marshalling: 20%
  - Rack: 20%

Mandatory spares: Refer mandatory Spare Section
3.0 DESIGN PHILOSOPHY

3.1 GENERAL

3.1.1 This Document together with the attachments covers the minimum requirements for the design and engineering of instruments and control systems, complete with all accessories, materials and special test equipments for the Project. In addition to above, specifications/requirements for any of the instruments / system oriented items given in the process package shall also be taken care by the contractor.

3.1.3 This document provides in detail, the minimum qualitative requirements of most of the instruments / system oriented items. For instruments, where no such requirements are indicated in this document, the contractor shall submit the same for Owner / Owner Representative Approval.

3.1.4 Contractor shall also be responsible for detailing out the specifications of various instruments / system oriented items from the process licensor’s process packages. Contractor shall also be responsible for meeting all requirements arisen out of clarification sought from the licensor.

3.1.5 The requirements specified in ‘Standard Specifications for Instrumentation Work’ shall also be applicable for various package / sub packaged items in addition to Unit / Units of fertilizer complex.

3.2 CODES AND STANDARDS

3.2.1 Contractor shall refer various codes and standards indicated in clause. 1.3 of ‘Standard Specifications for Instrumentation Work’ in addition to PMC standards attached alongwith this package.

3.2.2 In general, Contractor shall carryout engineering as per IEC/BIS standards. Any other standard, if necessary, can also be referred by contractor during the execution of the job, without diluting the basic requirements, however with prior information to Owner/ Owner Representative. In any case contractor must furnish a list of codes and standards other than those specified in this document which shall be followed by them during engineering.

3.3 DESIGN REQUIREMENTS

3.3.1 OVERALL CONTROL SYSTEM STUDY

Distributed Control a system has been envisaged as main Control & Monitoring platform. All field Instruments & standalone systems shall interact with DCS to provide optimum and adequate information to plant operator for safe and efficient plant operation.

SIL3 certified PLC shall be used for Plant safety interlocks & ESD system, BMS PLC can be used for implementing ESD functions.

3.3.2 INSTRUMENT CONTROL AND OPERATING PHILOSOPHY

3.3.2.1 Instrument control and operating philosophy has been decided considering following process units which are licensed by various process licensors:
3.3.2.1.1 PROCESS UNITS

For PLANT contractors scope cover all field related activities, specific system related items and engineering/co-ordination related activities for the systems procured by owner/PMC.

3.3.2.2 For monitoring & controlling the plant DCS / ESD is envisaged as per the architecture enclosed elsewhere.

3.3.3 INSTRUMENT DESIGN CRITERIA

3.3.3.1 The ‘Instrument Design Basis, together with ‘Standard Specifications for Instrumentation Work’ and other standard specifications enclosed alongwith this document provides the guideline for design, selection and detailed engineering of instrumentation.

3.3.3.2 All residual basic design and detailed engineering shall be carried out by contractor considering requirements specified in ‘Instrument Design Basis’. In case of any conflict between ‘Instrument Design Basis’ and requirements specified by various licensors in the process package, the requirements must be clarified with Owner/PMC before proceeding.

3.3.3.3 The instrumentation selected for the units shall be rugged in design and must be well proven in the hydrocarbon industry. Prototype design or equipment of experimental nature or design undergoing testing etc. shall not be selected and supplied.

Following criteria must be applied before selecting a particular instrument item:

a) For Instrument Items (Other than Systems)

The instruments as being offered/supplied should have been operating satisfactorily in an hydrocarbon industry like Nitric Acid, Ammonium Nitrate Plant, Fertilizer, Refinery, Petrochemical and Gas Processing Plant POWER Power plants under similar process conditions for at least 02 years. from the bid opening date.

b) For System Oriented Item

i) The system (with all its sub-systems) as being offered/supplied should have been installed and operating satisfactorily in an Nitric Acid, Ammonium Nitrate Plant, Fertilizer, Refinery, Petrochemical and Gas Processing Plant for at least 02 years (as collaborated by user certificate).

ii) The system should be supplied engineered & tested from a factory from where the system/sub-systems as offered / supplied, engineered & tested have already been supplied and meet the criteria b(i) above.

iii) All the activities including engineering should be carried out by the agency which have carried out the similar activity in the past and meets the criteria b(i) above.

iv) The system should be supplied by the manufacturer in the fully engineered condition or should be supplied by the manufacturer’s representative/subsidiary who have proper infrastructural facilities and meets the criteria b(i) above.
v) In any case, the manufacturer whose system is being offered/supplied should have a local representation/subsidiary which has the proper infrastructural facilities like engineering, installation, maintenance, testing, spare part support, system fault diagnosis and other related logistic support. Systems which don’t have the local base should be avoided.

3.3.3.4 Control systems shall be designed with a minimum availability requirement of 99.99% with a MTTR figure of 8 hours. Minimum level of redundancy have been specified in the package. Additional redundancies if required, must be provided by contractor to meet these specified availability requirements.

3.3.3.5 Power supply distribution scheme for instrumentation shall be fully coordinated with overall power distribution scheme. Proper fuse coordination, number of feeders, Isolation levels etc. must be evaluated during design. System loads and non-UPS loads shall be powered by two sets of separate isolated feeders by using isolation transformer in non-system related loads. Contractor must ensure the termination and distribution of all these incoming and outgoing feeders with power distribution cabinet.

3.3.3.6 Contractor shall ensure a fully integrated, safe and secure grounding system for the specified units of fertilizer complex, of which instrument grounding system shall form a part. The earth pits wherever necessary e.g. for instrumentation systems, analyser systems or local panels shall be provided by contractor based on the requirements.

3.3.3.7 Contractor shall select instruments in classified area as per clause 2.4 of ‘Standard Specifications for Instrumentation Work’. However contractor to note the following:

a) In general, intrinsically safe philosophy shall be followed for all inputs and solenoid valves outputs in the hazardous area except for MCC/PCC inputs/outputs. The barriers shall be selected based on entity parameters by Contractors, which shall meet the gas group area classification requirement.

   Contractor shall select the barrier based on the following requirements:
   - The barrier shall be of latest/ enhanced available versions of makes selected
   - The model no. selected should be proven as per the criteria specified
   - The barriers selected should have back-up support and representation available locally.

   Contractor to ensure that the instruments selected are compatible to the selected barriers.

  c) Instruments, which are not available as per their standard design from any reputed manufacturer as intrinsic safe, can be supplied in flameproof design. All such instruments shall be certified flameproof for the area classification and requirements indicated in clause(b) above.

  e) Intrinsically safe instruments shall be as per para 2.13 of ‘Standard Specification for Instrumentation work’.

3.3.3.8 The size indicated on P&IDs for control valves, safety valves and instruments requiring sizing (i.e. flow meters, Breather valves, flame arrestors etc.) are indicative only. The final sizing for control valves, safety valves, orifice assemblies, flow meters, breather valves, flame arrestors requiring sizing or any other line mounted instrument requiring sizing is contractor’s responsibility. In case of change in the instrument size from those specified in P&ID or in the Data-Sheet the same shall be carried out by contractor after obtaining approval from the licensor/ owner/PMC.

   Any change in instrument size or revision in line sizes because of sizing shall be carried out by contractor without any implications.
3.3.3.9   All limit switches shall be of proximity type. Mechanical type (microswitch or similar type) of limit switches shall not be used.

3.3.3.10   All solenoid valves in the field shall be certified intrinsically safe with a compatible isolating barrier in the control room. The solenoid coil design shall be suitable for working continuously with the specified voltage levels. The corresponding barrier selection should ensure proper functioning, compatibility and certification considering voltage level, current levels & the coil resistance for the selected solenoid valves.

3.3.3.11   Bearing and temperature monitoring of the motors. Bearing and temperature monitoring of all the motors shall be monitored directly from DCS. In case of Machine Monitoring System provided for an equipment, the bearing temperature element shall be hooked up to Machine Monitoring System. Contractor shall provide all such signals which have been indicated in the Rotating Equipment electrical sections of this document, in the control room. P&IDs shall also be updated by the contractor to show all these signals along with tag nos. The instrument details provided by the contractor for DCS configuration must include all details of all such tag nos. including range, alarm settings, type of sensors etc.

3.3.3.12   Indian Boiler Regulation (IBR) Requirements

3.3.3.12.1   Pressure relief valves (boiler drums, desuperheaters and steam lines before pressure reducing station) shall be designed and supplied as per ASME Section I or Indian Boiler Regulation (IBR) in line with pressure vessel design code. All items including safety/pressure relief valves in IBR service shall have IBR certification.

a)   In case of safety valves in IBR service, the type of valve shall be as per regulation no. 292 with 5% over pressure and 5% blow-down and shall be provided with following certificates:
    i)   IBR Form-III C certificate of manufacture and test of boiler mountings and fillings.
    ii)  IBR form III construction certificate of manufacture and test as per item 11.
    iii)  Type test certificate from IBR authority as per appendix-L of IBR for the valve series supplied.
    iv)   Radiography of all castings as applicable.

b)   In case, ASME Section I valves are supplied, it shall be ‘V’ stamped and should have the certificate from ASME certified laboratory.

c)   The discharge capacity of these safety valves shall be calculated as per IBR regulation no. 293 a, b & c.

d)   Equipment nozzle length and sizes shall meet the corresponding code i.e. ASME Section- I / IBR Requirements.

3.3.3.12.2   Safety valves in utility steam network after main pressure reducing station) shall be as per ASME Section VIII as a minimum with 10% over pressure and 7% blow down unless otherwise indicated in the data-sheet. These valves shall be provided with IBR form-III C certificate.

3.3.3.12.3   All on line instruments such as control valves, Thermowell, flowmeters, orifice flanges and level instruments like level gauges, Displacer type level transmitters etc. shall be provided with IBR Form-III C certificate.

3.3.3.12.4   For pressure gauges on steam service the range shall be selected as below;

a)   For pressure below 35 kg/cm2g, the range shall be 2 times the max. working pressure.

b)   For pressure above 35 kg/cm2, the range shall be 1 1/2 times the max. working pressure.
3.3.3.12.5 Installation items like syphon, condensate chambers, pipe and pipe fillings for the instruments installed in the IBR lines, and steam tracing filling shall have form III C certification.

3.3.3.13 Direct temperature, level switch, flow switch and pressure (low) shall not be used but these are to be achieved using field transmitter. Transmitters analog signal shall be directly connected to DCS/PLC as per requirements.

3.3.3.14 Pump discharge pressure gauges are to be either diaphragm seal type with capillary with capillary or the gauges are to be mounted at a distance from the discharge pipe through longer impulse line and proper support to minimise vibration. In any case the mounting location of these gauges shall be as per operational requirements. Glycerin filled gauges shall be used for pressure fluctuating services like reciprocating compressors and pump discharges etc.

3.3.3.15 For differential pressure transmitters with tapings at long distances apart particularly in columns, separate pressure transmitters are to be considered and differential pressure shall be calculated in DCS.

3.3.3.16 All contacts in the intrinsically safe service shall be gold plated. Colour of the canopies shall be finalised during detailed engineering.

3.3.3.17 All the instruments shall be provided with canopies of adequate size to protect instruments from direct rain & sunlight. All such canopies shall be prefabricated type.

3.3.19 All instruments and equipments shall be suitable for use for specified site climatic conditions and industrial environment in which corrosive gases and/or chemicals may be present. In general, all instruments and enclosures in field shall be dust proof and weatherproof to IP-65 as per IEC-60529/IS-13947 to be considered, and secure against the ingress of fumes, dampness, insects and vermin. All external surfaces shall be suitably treated to provide protection against corrosive plant atmosphere.

In case of contradiction between licensor specifications, approved P&ID and this design Philosophy, P&ID shall be final document and shall prevail.

The design of electronic instruments shall be in compliance with the electromagnetic compatibility requirements as per IEC 61000-4 'Electromagnetic compatibility for Industrial Process measurement and Control equipment'.

a. In general, instruments, used in hazardous areas shall be intrinsically safe and shall be selected based on entity parameters. However where specific type of instrument is not available in IS as standard, the same can be considered with flame proof only. All field Instruments shall be suitable for Zone 2 IIC T3, EExib shall be certified by a statutory body with gas grouping as per requirement. In addition to any certification depending on manufacturing location, additionally instruments shall be certified by CCE, India irrespective of the origin. Certification agency will be vendor standard. Also indigenous flameproof equipment shall comply with BIS requirement. Enclosure housing material for all transmitters, Temperature elements, positioners shall be Die-cast Aluminum epoxy painted. In general purging is not acceptable for Instrument enclosures.

b. Material of construction and end connection rating shall be as per piping material specification as a minimum. However thermowell with it’s flange shall be as a minimum SS316. It is LSTK Contractor responsibility for correct selection of materials for all instrument items.
c. In general, transmitters shall be used for all process alarms/trips including for Pump seal and all other applications. Transmitters shall be provided instead of level/flow/pressure or temperature switches. Use of switches to be avoided and this requirement shall govern over other specification specified elsewhere.

d. The instruments like control valves, orifice flanges, level instruments, thermowell etc., coming on pipes and vessels under IBR shall be certified by IBR or IBR authorized representative.

e. In general, field transmitters shall be smart type with LATEST REVISION OF UNIVERSAL HART PROTOCOL. However where in some specific type of instruments, it is not available, like mass flow meters, analyzers etc., the same will be non-smart. All field instruments shall be SIL -2 certified.

f. for steam drum level measurement, additionally one GWR suitable for boiler application shall be provided.

The SMART shall be with “Advanced diagnostics” capabilities.

The rangeability and accuracy shall be as below:
- The Overall rangeability shall be 1:100 for Normal transmitters with calibrated accuracy of ± 0.075% of span within a turndown ratio of 1:10.
- The Overall rangeability shall be 1:30 for Draft Range Transmitters (<500 mm WC) with calibrated accuracy of ± 0.15% of span within a turndown ratio of 1:10.
- The Overall rangeability shall be 1:100 for Diaphragm seal transmitters with calibrated accuracy of ± 0.2% of span within a turndown ratio of 1:10.
- Transmitters shall have minimum static pressure rating of 100 kg/cm²g except for very low-range for which the static pressure will be considered suitably based on the availability.

The accuracy of temperature transmitter with RTD shall be as follows
- For temperature above 350 °C, equal to or better than ± 0.075% of full scale
- For temperature in range of 150°C to 350 °C, equal to or better than ± 0.15% of full scale
- For temperature below 150°C , equal to or better than ± 0.25% of full scale

The accuracy of temperature transmitter with cold junction compensation for thermocouple, shall be as follows
- For temperature above 350 °C, equal to or better than ± 0.2% of full scale
- For temperature in range of 150°C to 350 °C, equal to or better than ± 0.5% of full scale
- For temperature below 150°C , equal to or better than ± 0.75% of full scale

The accuracy is defined as the combined effect of repeatability, linearity and hysteresis.

The transmitter response time shall be as follows as a minimum
- For range of 760 mmWC and above, 500 milliseconds or better
- For range of below 760 mmWC , 1seconds or better

f. Threaded end connections shall be to NPT as per ANSI B 1.20.1. Flanged end connections shall be as per ANSI B 16.5.

g. All standards to be followed in this project to be reviewed and approved by PMC / OWNER for avoid any mistake during execution stage.

h. For 3500 series vibration proximeters screwed terminals to be used for cable connection not push type connectors and I/O modules with built in barriers.
j. All logic should be implemented in main ESD PLC.

k. For machine monitoring system vibration/temp/speed probe cables to be taken through flexible armoured conduit up to JB. Un armoured cables shall be routed through GI Conduit pipe.

l. For the following instruments, as applicable, involvement of OEM engineer is required during installation as well as during commissioning. For ASC & Performance controller, OEM should present for tuning and surge test during commissioning:

   a) DCS& PLC System (including IAMS/ AIMS / CCTV etc.)
   b) Deleted
   c) Machine monitoring system.
   d) Stack & Process Analyzers
   e) Gas Detection System.
   f) Special Control Valves.
   g) Flexible thermocouples
   h) Mass flow meters & Vortex flow meter.
   i) RADAR type instruments.
   k) Any other special field instruments.

m. In general, intrinsically safe philosophy shall be followed for all inputs/outputs in Hazardous area except for MCC/PCC inputs/outputs.

n. All junction boxes shall be certified for weather proof with IP 65 certification for IS signal. For non IS signals, Junction boxes shall be flame proof for IEC Zone 1 & Gas group IIC Ex. Proof.Anti-corrosive paint shall be provided, Junction boxes

o. All Contacts shall be Gold Plated 2 SPDT.

p. All solenoid valves shall be of SS body.

q. For pump seal plan, guided wave radar level transmitter to be used to implement alarm etc. Level & pressure switches should not be used.

r. In general, the logic for the package units shall be executed in unit main plant PLC. All package unit logics shall be realised in main plant PLC only

t. All spares hole of JBs, T/C head etc to be plugged with metallic plugs.The metallic plugs, Junction box hinges, Handle, DIN rail, Allen screws shall be SS material of construction. Cable glands shall be provided with Cables shrouds.

u. Ultrasonic flow meters should be used for flare flow measurement.

v. Transmitter body shall have integral vent & drain facility. External manifold for vent & drain is not acceptable. For all type of transmitters glass filled Teflon O-ring to be used for oval flange. Bottom entry process connection is not acceptable.

w. For piping impulse, integral 3 ways manifold should not be used.

x. For instrument high-pressure drain vent line cap should not used. In such cases blind flanges to be used.
y. Draft transmitter open to atmosphere port to be connected with helical copper tube coil and the coil free end to be put inside a perforated pot with ceramic balls to avoid spurious tripping during high wind velocity.

z. Deleted

aa. Intrinsically safe barrier shall be active isolating type. Barriers must be selected on entity concept. It is desirable to use one make of barrier for entire plant; make shall be MTL/P+F. Barrier shall be with three-port isolation type.

bb. Junction box shall be of die-cast aluminum alloy (LM-6) anti corrosive painted. All junction box shall be weatherproof to IP-65 as well as flameproof. Junction box shall have screwed covers. All cable entries to junction boxes shall be side or bottom.

dd All instruments shall be of latest models with proven track record of minimum 2 years and spares shall be available for 10 years. No prototype instrument of an experimental nature shall be offered or supplied. No instrument requiring special maintenance or operating facilities shall be offered.

e.e Devices and equipment located in indoor/air-conditioned areas shall be designed to suit the environmental conditions indicated elsewhere and shall be suitable for continuous operation in the operating environment of G3.

f.f All Instruments connected to Process & Machine interlock circuit which leads to plant trip shall be from three separate transmitters to implement 2oo3 logic, this includes machine monitoring signals for vibration, over speed, temperature, etc.

g.g No tripping parameters shall be interfaced through serial communication and soft links, only hardwired signals shall be used. Transfer of data through serial link from DCS to PLC and vice versa shall be used only for monitoring purpose and not for control & trip.

h.h Emergency shut down push buttons of all the electrical drives shall be connected directly through MCC and not through PLC. Location of Auto / manual station as per process requirement. If auto / manual station is located in field, the same shall be directly connected to MCC.

i.i Two separate AC distribution board (Dual ACDB) fed from parallel redundant UPS are essential for Instrumentation power distribution system for the improved reliability. Each DCS AC DB shall be fed from redundant UPS feeders & shall have with static switch for change over automatically without power interruption in case of any incomer failure.

jj UPS supplies shall not be used for utilities supplies cooling fans, panel/cabinet lighting etc. A separate non-UPS supply shall be used for the same.

k.k A summary of all critical UPS alarms shall necessarily provided in DCS and hardwired annunciation in control room or any manned location

ll Only copper cables & tin-plated copper lugs shall be considered for instrumentation power distribution system.

mm UPS battery back up should be available for a minimum period of 60 minutes at full load condition. The same to be ensured during capacity discharge test of battery bank during pre-commissioning activities.
n.n Protection coordination with respect to fuse/MCB ratings from the supply source ACDB/DCDB to downstream distribution panels shall be thoroughly studied by the system designers/OEM and documented as a part of the system documentation and be implemented accordingly.

o.o Minimum two BPS shall be configured for powering all control & field devices.

p.p Use of multiple set of BPS (Bulk Power Supply) of smaller capacity in place of single set of higher capacity per unit shall be considered.

q.q A set of redundant-BPS shall be fed from two separate AC feeders. Power looping in and out shall be avoided/eliminated.

r.r The loading of individual BPS should be such that the failure of single BPS shall not result in loading of the other operating/redundant BPS beyond 70% of their individual rated capacity.

s.s “BPS failure” alarm shall be provided in hardware annunciation system and in DCS with highest priority.

t.t PLC consoles shall be considered in the new system to understand the status of the “Logic Flow” of the respective systems.

u.u Conformal coating application may be ensured in DCS/PLC cards, which are installed in control rooms or in the field-mounted control systems.

v.v SOV’s shall be IS type only. For SOV with FMR provision, tamper proof type FMR shall be used. The trip SOVs shall be in redundant pairs and configured/connected for increased reliability. The signal for these redundant SOV’s shall be driven through separate DO contact. All Coils of the SOV’s shall be hermetically sealed.

w.w For the shelter analyzers, Temperature & pressure indication shall be provided at DCS for monitoring.

x.x.1 Wherever RCC cable trenches will be used. RCC Separation shall be done within the trench for laying power cables.

x.x.2 No perpendicular crossing of Instrument and electrical cable trenches / tray. Separation of electrical & instrument cables as per ISA.

x.x.3 Road crossing of trenches shall have be done through Box Culverts.

y.y. Instrument cable crossing with electrical cable in cable trenches shall be avoided. If unavoidable reasons, Instrument trench can take over the top portion.

z.z All drawing / sketches attached with the tender are indicative only. The installation shall be done as per engineering design philosophy and process licensor by the Bidder after obtaining owner / consultant’s prior approval before erection.

a.a.a The Bentley Vibration and Temperature monitoring system shall be located in Control Room with field display unit in LCP. BN system Modules shall be mounted with Internal Barriers.

a.a.c Corrosion Monitors shall be provided in control rack room.
a.a.d Flow (with Pressure and temperature correction), Pressure and Temperature Measurement shall be required for common facilities like Inst Air, Cooling Water, Steam etc.

a.a.e G3 coating as ISA standard for DCS/PLC system hardware from OEM.

a.a.f UPS Voltage and Current trends to be made available in DCS. Provision for repeating common fault alarm to the substation to be provided.

a.a.h All Printers Shall be Laser Printers

a.a.i Latest revision of Hart protocol shall be used in universal Hand Held Configurator.

a.a.j NACE to be considered for Sour services.

a.a.k H₂S, HC detectors shall be considered as per P & ID

a.a.l Deleted

a.a.m There shall be one separate controller in DCS for all the foreign device interface

The Total Number of controllers shall be decided based on scan time and controller loading as per ITB.

a.a.n Functional distribution of I/Os shall be section wise for boiler for HT & LT, for foreign device interface

a.a.q Adequate number of smoke detectors, heat detectors, fire alarm system, rodent repellent (electronic type) shall provided in the Control room.

a.a.r Control room shall have aesthetic looking flooring, false ceiling and lighting arrangement. Bidder to take approval from PMC/OWNER for control room ambience.

a.a.s. Interpanel distances 1.6 m.

a.a.v Clean Agent System, HVAC shall also be provided in the control room.

3.3.3.20 APPROVAL / REVIEW OF DOCUMENTS

Approval category of Documents

- DCS & PLC Package.
- Package PLC Control system
- Process & stack analyzers.
- Control valves, Special Control valves
- Shutdown valves
- Gas detection & CC TV system
- Vibration Monitoring system
- Local Control Panel
- Package vendor Control panels
- Field Transmitters
3.3.4 EMERGENCY SHUTDOWN PHILOSOPHY

3.3.4.1 The Emergency Shutdown (ESD) system is designed to monitor key process variables and equipment and respond automatically or to operator initiated commands, in such a way as to reduce the risk of hazardous or destructive incidents.

3.3.4.2 The ESD system shall be independent of the primary control system and will perform the following functions regardless of the availability of the DCS:

a) Monitor dangerous conditions and take appropriate automatic shutdown action.

b) Respond to manual requests for shutdown, Reset and Override from the operator consoles or from the field as per requirements.

c) Record on a suitable Sequence of Event Recorder (SER) all events / alarms and actions taken by the ESD system.

d) Indicate to the control operator that a trip has been initiated and has been successfully completed, or has not been successfully completed.

3.3.4.3 All Process interlock inputs shown in the P&ID shall also be configured in the shutdown PLC.

3.3.4.4 ESD Logic for process packages like. Process compressors etc shall be executed in the main PLC unless specifically recommended otherwise by process licensor or sub-package supplier because of performance guarantee requirements.

In case separate PLC is used for such packages, the configuration and peripheral requirement shall be same as the main PLC. All such package PLC’s shall be located in main control room and shall be serially interfaced to DCS using dual redundant link. For all Package PLC’s, all Interlock graphics shall be made available with First out feature in DCS.

3.3.4.5 To ensure proper implementation of Engineering in line with our requirements indicated elsewhere in the document, contractor must furnish the I/O count including I/O count for all such packages in their offer with a reasonable accuracy as defined elsewhere. However final I/O count shall be based on the detailed engineering.

Generally dedicated sensors have been used for monitoring/control and shutdown

For 2oo3 logics separate I/O cards shall be used for each signal. ie; each one of the 3 signals shall be connected to three different cards, The PLC cards and racks shall be segregated equipment wise. Remote start commands for standby and main equipments shall be from different I/O cards. Bidder may also note that all the 3 signal in a 2oo3 logic shall be terminated in three different Junction boxes.

3.3.5 PACKAGE AND SUB-PACKAGE CONTROL PHILOSOPHY

3.3.5.1 The control philosophy for the packages / sub packages shall be as defined in the Instrumentation Design Basis in this package and process package. However the execution philosophy as defined in ‘Standard Specifications for Instrumentation work’, shall be followed in general.
3.3.5.2 Detailed P&IDs of the packages/sub packages shall be submitted by the contractor to Owner/PMC, showing the complete scope and connectivity to the central control systems (DCS/PLC).

3.3.5.3 Contractor shall also show in the P&ID’s all instruments and control systems necessary for safe and efficient operation of the various packages / sub packages, which are not specifically listed in this document but are required as per contractor's/manufacturer’s experience/recommendation. All such instruments and their accessories shall also be supplied by the Contractor.

3.3.5.4 For pump seal plan instruments as provided by pump supplier, their connectivity to main control system including supply of cables and junction boxes etc. shall be in Contractor’s scope and shall be shown in the P&ID.

3.3.5.5 For the packages being supplied by contractor, it is preferred that the complete Instrumentation engineering and supply shall be through the equipment sub-supplier, considering a package approach.

3.3.5.6 All package units shall have local panels which shall be used for start up, shut down and normal critical operations only unless otherwise indicated in the process package. Following points shall be kept in mind while engineering the local panels:

a) Panel shall only house switches/pushbuttons, status lamps, important alarms. No electronics/electronic devices or Instruments except intrinsically safe indicators (if necessary) and explosion proof (EEExd) alarm annunciators shall be located on the local panel. The alarm annunciators shall be integral type and shall be certified explosion proof by statutory authority.

b) In general, the logic for the package units shall be executed in unit PLC. Where unavoidable, contractor may use separate PLC. However such unit must be located in the control room and shall preferably have same make, model no. & configuration as that of unit PLC being procured by purchaser. A laptop PC with all required softwares shall be provided with package PLC as configurator.

c) The pushbutton/selector switches and lamps on the local panel shall be certified flameproof. However process switches shall be intrinsic safe with barriers in the control room/local panels as applicable. The pushbuttons/switches connected to MCC/PCC/substations shall be also be certified flame proof.

d) Anti Surge Controller, if required, shall be a separate dedicated controller in redundant configuration and shall be which should be located on hardwired console in main Control room by others.

e) Deleted

3.3.6 JUNCTION BOXES AND CABLELING PHILOSOPHY

3.3.6.1 Cable Routing

3.3.6.1.1 Contractor to note that overhead tray shall be used for routing multicables within the unit. The main tray shall be routed over the pipe rack with suitable accessible location.

3.3.6.1.2 From field junction box to over head cable tray, the cables shall be routed through perforated aluminium trays. Single pair cables from instrument to junction box shall be through perforated trays. Cable glands shall be provided at instrument end and junction box end and at local panel end (as applicable). Cable glands at control room end except for the cables connected to contractor supplied panels/cabinets in control room shall not be in their scope...
3.3.6.1.3 Wherever trenches are required, Contractor to provide RCC trench for routing of cable. Buried cable laying shall be avoided unless otherwise necessary which shall be approved by owner/PMC. All cable trenches shall be back filled with sand after cabling is completed.

3.3.6.1.4 The cables entry to main control room shall be through trenches. Multiple MCT blocks of appropriate size shall be provided by contractor for cable entry in order to avoid congestion.

3.3.6.1.5 Once inside the control room building, the cables shall be routed through the cable tray under the false flooring. The cables shall be segregated in the main cable tray/tray truck route as per unit and type of signal carried by the cables. The cables from the main trunk route shall be routed in feeder or link trays to the respective cabinet. The contractor shall be responsible for:

a) To supply, support and lay the main trunk cable tray/trays, feeder/branch/link trays to cabinets.

b) to provide all supports necessary for main /feeder/link /trays &trays.

c) Segregating all cables in the main trunk tray/tray and feeder trays and laying these upto the cabinets.

3.3.6.1.6 Proper routing of following type of cables shall be planned within control room as well as in the field trays, trenches, analyzer shelters etc. to ensure ease of cable installation and to prevent the interference among the cables:

- IS Analog 4-20 mA cables
- Non-IS Analog 4-20 mA cables
- Contact/alarm cables
- IS Shutdown cables (for solenoid valves)
- Power cables
- System communication cables

3.3.6.1.7 Cable Tray and Trays

a) Perforated aluminium tray shall be used for cable routing between junction boxes & control room and shall be routed in the topmost tier of pipe rack. Trays shall be considered only for branch cable routing.

b) Contractor shall provide continuous channel for support of the overhead tray and the same shall be suitable for a load considering 100% filling of the tray by cables. However as a good engineering practice, trays shall be sized considering 65% occupancy of the tray by cables. For ladder and angle trays Contractor shall provide support at a minimum interval of 1.5 meter.

c) The Tray shall be fabricated in general as per Tray fabrication attached elsewhere in this document. All tray/trays shall be of perforated aluminium.

e) Plant communication cables shall run in the middle compartment of the cable tray whenever no instrument cable is laid in this area. In case contractor plans to lay any type of instrument cable in the middle portion e.g. fiber optics or serial cable, separate tray/tray shall be used for laying plant communication cables. No electrical cables shall share the instrument cable tray including plant communication cable.

**ELECTRICAL FIELD WIRING**

Colour Coding for cables as per IEC.
a) Instrument electronic signal & alarm cables, single pair shall be 1.5 mm² and multi pair shall be 1.5 mm² twisted in pair individually and overall shielded with aluminum Mylar tape with drain wire and armoured.

b) Control wiring for actuating devices and solenoid valves of the interlock and shutdown system shall generally be 1.5 mm² armoured cable.

c) Multipair extension cables for Thermocouples if required shall be 20 AWG single conductor twisted pairs, armoured, individual pair and overall aluminum Mylar shielded with over all drain wire. Single pair extension cables shall be armoured cable with 16 AWG single conductor wire. The Triad single and multipair cables shall be 1.5 mm² armoured type.

d) The power cables shall be Cu contrayor and the size shall be selected based on voltage drop. The minimum size shall be 2.5 mm² armoured.

e) All cable glands shall be of SS316 and they shall be of double compression type suitable for armoured cables. All cable glands (SS316) are to be provided with PVC shroud. Flameproof glands may be provided wherever required.

PVC insulated cables shall be used. Insulation type shall be verified by respective LSTK Contractor during detail engineering and select as required.

g) For longer distances cablesizes shall be selected based on voltage drop.

h) Only 12 pair multicables shall be used for signal, control and thermocouple extension cables. 6 triad or 8 triad shall be used for RTD if required. The cable type for gas detectors is also to be included.

i) Screened twisted pair cables shall be used proximity switches, 24VDC SOVs and for cables between MCC/substation to DCS/PLC.

j) All instruments cables shall be flame retardant low smoke cables as minimum.

k) The DCS data bus outside control room / rack room shall be fibre optic armoured.

l) Multipair JBs for DCS signal & PLC signals should be separate. PLC/DCS signals should not be connected in the same JB.

m) All field mounted emergency push buttons for heaters & critical pumps/motors or any other operation should be with glass cover to avoid inadvertent operation of these switches.

3.3.6.1.8 Trench

a) Where ever cables are to be routed underground, these shall be laid in RCC trenches. RCC trenches shall have a minimum width of 2000 mm and depth of 1000 mm with angle inserts provided at 100 mm above the bottom of the trench at every 1500 mm interval. All RCC trenches shall be provided with removable RCC covers.

RCC trenches shall be sized considering future expansion of the fertilizer complex. Trench space equivalent to 40% additional cables of largest size shall be considered while sizing these trenches.
c) Each underground cable (concrete trenches) shall be provided with identifying SS Plate tags of lead securely fastened every 25m of its underground length with at least one tag at each end before the cable leaves / enters the ground.

d) For any crossing of cable trench (underground) with electrical trench, it must be made at 90° only and the cross-section area of the trench must be same at the point of crossing. The trench should have 20% space as a minimum for the future excluding the standard space for sand filling and cover.

3.3.6.1.9 Since all local panels shall have bottom entries for cables, the cable trench may be used for routing cables upto panels. The length of cable trench shall be kept minimum. The platforms where panels are installed shall be raised by 150mm above the finished level.

3.3.6.1.10 Road crossing of trenches shall have been done through Box Culverts designed for the Heavy vehicles/ crane Movements.

If for some reason, box culvert is not possible, then At road crossings, RCC cable trench shall be provided by the contractor for the cable run. Trench slabs shall be designed for the Heavy vehicles/ crane Movements.

3.3.6.2 Multicables

3.3.6.2.1 All multicables between field / analyzer shelters & main control room shall be as per clause 12.4 of standard specification for instrumentation work and shall follow the following philosophy as a minimum:

a) Signals: 6/12 pair individually and over all shielded (4-20 mA or switch contact) (screened) and armoured, twisted, 1.5 mm2

b) Thermocouple: 6/12 pair TIC extension cable

c) RTD: 8 Triad 1.5 mm2

d) Solenoid valves: 6/12 pair individually and overall shielded, armoured, 1.5 mm2

e) LEL gas detector: 8 Triad 1.5 mm2

All system cables/fiber optic cables in the field shall be routed in HDPE Hard pipe. Fillings shall be used for joining the HDPE pipe. HDPE pipes shall be ORANGE in colour with BLACK fillings. All system cables/fiber optic cables shall be routed in the middle 150mm portion of the tray. Wherever it is absolutely necessary to route these cables underground, it should be routed in the RCC Trenches only. Within the control room all system cables shall be routed within an enclosed perforated aluminium. Separate route should be followed for redundant system cables.
f) All multipair/multi-triad cables in area containing hydrogen (IEC Gas group IIC or NEC Gas Group B) shall have primary insulation of polyethylene with maximum capacitance of 100 pF/m. All other cable specifications shall be same as specified in 3.3.6.2.1 above.

g) Any other cable requiring lower capacitance necessary because of type of instrument used (for performance), intrinsic safety (for entity parameter compatibility match), for system compatibility (e.g. with HART maintenance system) etc. Contractors should use cables specified in (f) above.

3.3.6.2.2 Contractor shall clearly state if any of the above cable does not suit vendor’s instrument requirements in the offer stage itself and indicate type of the cable required.

3.3.6.2.3 In general, 80% of pairs of multicables shall be used i.e. connected to instruments. Remaining pairs shall remain unused however same shall be suitably terminated at junction boxes/Local control panels/Marshalling racks etc.

3.3.6.2.4 The multicore cables entry shall be from the bottom of the junction box. Two cable entries shall be provided for this purpose in the bottom of Junction box. Proper junction box numbering, cross-direct ferruling of the termination along with the copper lugs shall be at both the junction box end and the control room end.

3.3.6.3 Fire Resistant / Survival Cables

Any cable which is necessarily required to keep its integrity even in case of fire or where specifically indicated in P&ID or any other document attached elsewhere in this document, all these cables shall have mica insulation and shall be as per IEC-331 CAT-A type.

3.3.6.4 Junction Box

3.3.6.4.1 In general separate junction boxes shall be used for the following:

a) 4-20 mA DC signals (IS)

b) 4-20 mA DC signals (non-IS)

c) Thermocouples (if used)

d) RTDs (if used)

e) Contact signals (Field switches, push buttons etc.)

f) Interlock and shutdown signals (Solenoid valves)

g) Power supply to various instruments.

h) Gas Detectors

h) Vibration signals

3.3.6.4.2 Separate junction boxes shall be used for signals connected to PLC and to DCS. No signal shall be shared between them in the field junction boxes.

3.3.6.4.3 3-way junction boxes shall be used for connecting the field transmitter and field mounted analog intrinsic safe indicator in series with control room receiver.

3.3.6.4.4 The multi-cable entry for 6/12-pair & 8 Triad JB shall be 1” & 11/2” NPT (F). Each junction box shall be provided with 2 multi-cable entries from the bottom of the junction box with one plugged with weather proof plugs.
All spare cable cores shall be terminated in the Junction box, at the marshalling panel end and wired through spare barriers / isolators or relays (as the case may be) right upto the corresponding spare channel of I/O module.

All spares hole of JBs, T/C head etc to be plugged with metallic plugs. The metallic plugs, Junction box hinges, Handle, DIN rail, Allen screws shall be SS material of construction. Cable glands shall be provided with Cables shrouds.

3.3.6.4.5 Junction boxes, cable glands and accessories shall be weather proof in general. Slipper type PVC sleeves shall be used over cable glands for all cable entries in junction boxes to avoid water entry in junction boxes. In case of explosion-proof components used (only for packages), the respective junction boxes, cable glands and accessories shall be certified weatherproof and explosion proof.

3.3.6.4.6 All analyser sample lines shall have electrical tracings.

3.3.6.4.7 The junction boxes in the field as well as in local panel shall be provided with sufficient number of terminals to terminate all the pairs of multi-cable (including spare pairs) and shields of individual pairs as applicable.

3.3.7 FLOW METERING PHILOSOPHY

Sizing calculation shall be carried out in “Intools” (Smart Plant Instrumentation).

3.3.7.1 Contractor shall follow the flow metering philosophy as recommended by process licensors in the P&I D’s or the Instrument data sheet in the process packages. Wherever type of flow element is not shown or indicated in the process package, guidelines provided in standard specifications for Instrumentation work elsewhere in this package shall be followed.

3.3.7.2 In general, orifice plate shall be used as main flow element unless other types are specifically recommended or required because of specific process conditions like custody metering, rangeability, accuracy, line size, flow velocity, pressure drop, nature of process fluid etc.

3.3.7.3 All flow calculations/sizing calculations shall be carried out.

3.3.7.4 The sizing calculations for flow elements like orifice plates, venturi tube and flow nozzles etc. shall be carried out as per licensor’s recommendations.

3.3.7.5 In case of multi-Transmitter installation on a single element, a minimum of two pairs of taps shall be provided in such a way that not more than two transmitters shall be installed on any tap. Each instrument shall be provided with isolation. Any other guidelines over and above this requirement if indicated in P&ID or in process package, shall supercede this requirement.

3.3.7.6 Orifice plates below 2” shall be avoided. When used below 2”, calibrated meter runs shall be used along with orifice plate. Integral orifice shall be used whenever specified in the process package. Any other guidelines over and above this requirement if indicated in P&ID or in process package, shall supercede this requirement.

3.3.7.7 Restriction orifice in critical pressure drop applications or excessively high pressure drops in liquid or gas service shall be multiple orifice only. Contractor must furnish sizing calculations and design along with the Purchase requisition.
3.3.7.8 Use of PD & Turbine meters should be avoided instead; mass flow meters to shall be selected. Multiple mass flow meters may be used if single meter is not able to meet the flow requirements.

3.3.7.9 Although the flowmeters shall be selected as per the process package/P&IDs, however wherever PD/ Turbine meters are shown in the P&IDs/process package, contractor shall bring the same to owner/PMC’s notice and replace the same with mass flowmeter if so confirmed by owner/PMC without any implication. Whenever indicated, ultrasonic flow meter shall be used for applications like flare flow measurement from the unit and highly viscous flow measurement.

3.3.8 INSTRUMENT PURGING AND FLUSHING

3.3.8.1 Purge type installation shall be used in plugging, congealing and viscous services wherever permitted. However contractor shall follow the recommendations given in the P&ID’s as a minimum.

3.3.8.2 In general, continuous flushing oil purge and gas purging (fuel gas/nitrogen) shall be provided for all transmitters in heavy residue services, congealing/toxic service. However purge media shall be selected as per P&ID.

3.3.8.3 Contractor scope shall include complete purge kit including rotameters, constant differential relay, non-return valves, restriction orifice/needle valve regulators etc. as per installation standards for purge installation.

3.3.8.4 All diaphragm seal instruments (in toxic, viscous and congealing service etc.) shall be provided with purge connection. In addition flushing block with a provision to vent and drain shall also be provided in all such installation.

3.3.9 HEAT TRACING AND INSULATION

3.3.9.1 Heat tracing and insulation of line mounted instrument shall be carried out as per line specifications. Similar philosophy shall also be followed for equipment mounted instruments.

3.3.9.2 Instruments mounted on jacketed lines and jacketed equipments shall be jacketed only. In case the jacketing of any particular instrument item is not possible, heat tracing may be selected after intimation to owner/PMC before proceeding ahead.

3.3.9.3 For all steam traced lines and steam jackets, a suitable type of steam trap must be provided for proper and efficient tracing. Separate dedicated steam trap shall be used for each instrument. Steam trap shall preferably be located on ground level with its outlet connected to drain funnel or as advised elsewhere in the package. Block & bypass shall be provided for each steam trap for maintenance. The steam traps shall be imported only. Items procured from local market shall not be accepted.

3.3.9.4 Wherever electric tracing is shown in the P&ID and selected for instruments and instrument lines, this must be suitable for the line temperature rating.

3.3.9.5 In addition to lines where tracing is shown, impulse lines of all remote mounted transmitters in negative temperature typically up to -100 C shall be steam traced to maintain vapour phase. Adequate care shall be taken to minimize direct heat into the main line by cold insulating the impulse line near the take-off.

3.3.9.6 Steam tracing shall be avoided inside any room/shelter. Typically, heat tracing required within analyzer shelter shall be carried out using electric tracing. Sample line for analyzer shall be electrically heat traced.
3.3.9.7 Insulation of all in-line instruments like control valves, safety valves etc. shall be done as per the line requirements. Also all direct equipment mounted instruments like level gauge, displacer/float type instruments etc. shall be properly insulated as per insulation requirements of the equipment on which these are installed.

3.3.9.8 Asbestos rope shall not be used for the insulation of impulse tubes. Instead contractor may utilise ceramic rope unless any other requirement is specified in this package. Proper protection shall be ensured whenever ceramic rope is used.

3.3.10 INSTRUMENT DRAINS

3.3.10.1 Instruments like displacer type level transmitters and level gauges in hydrocarbon service shall have drains connected to the close blow down (CBD) system. For any additional requirements, P&IDs/process package shall be followed.

3.3.10.2 The drain line material shall be as per impulse line material.

3.3.10.3 For purging and viscous services, the drains connected upto the CBD line shall be steam traced and insulated.

3.3.11 INSTRUMENT PAINTING REQUIREMENTS

3.3.11.1 All instrument impulse lines and instrument structural items shall be painted by the contractor.

3.3.11.2 The painting/coating shall be performed in totality for all instrument items such as:

a) All line mounting and equipment mounted instruments.

b) All instrument impulse piping.

c) All instrument structural items like G.I cable trays, G.I cable trays, instrument supports and tray/tray supports, instrument stanchion, impulse line supports etc.

d) All surfaces of GI items wherever repair has been carried out shall also undergo painting.

e) All cabinets/panels, base frames which have undergone repair at site shall also be painted.

3.3.11.3 The final coating on external surfaces shall be applied just before handing over the plant or commissioning of the plant.

3.3.11.4 Paint color of the canopies shall be decided during detailed engineering.

3.3.11.5 Name of the manufacturer, colour and quality of all types of primers and paints shall be subject to approval of the owner/owner’s representative.

3.3.12 INTERFACE WITH OTHER SYSTEMS

3.3.12.1 Apart from project interface with owner/PMC for various activities defined in this contract, contractor shall also be responsible to carryout coordination activities defined herein.
3.3.12.3 Bidder to provide total two remote Operator station with password protection n in the central control room, for Steam generation unit.

3.3.12.4 Optical fibre cable shall be redundant wherever used for communication including communication between Steam generation plant control room, CCR and main fire control room. The laying of the cable shall be done with different routes and some distance apart to avoid the blackout in the CCR in case of any eventuality.

3.3.12.5 Bidder to provide interface for CCTV and Telephone network with the central control room networks, Bidder may co–ordinate with other contractor to do the same.

3.3.12.6 Fire Alarm system shall be interfaced with the Central fire station, all the necessary communication up to the central fire system PLC shall be in bidder's scope. Including OFC and network switches etc. Any alarm generated in steam generation station unit shall be displayed at Fire Control Room. Repeater panel at central fire control station shall be in bidder scope.

3.3.12.7 All network switches must have redundant power supply with a DI contact configured in DCS for monitoring the healthiness of Network Switch power status in DCS.

3.3.13 ELECTRICAL/INSTRUMENTATION INTERFACE

3.3.13.1 In order to have smooth and trouble free engineering, a proper well defined methodology must be adopted to define the interface between Electrical and Instrumentation department.

3.3.13.2 In general, contractor shall follow the philosophy defined electrical & instrument interface to this document, for the interface between these two departments. Any change from this philosophy must, in principle, be brought to the notice of Owner/PMC.

3.3.13.3 Substation interconnection with PLC/DCS are to be made through unit multipair cable only. It should have dedicated laying route inside cellar room. All these cables should enter cellar through dedicated MCT blocks.

3.3.13.4 Separate Multi pair cables shall be laid for Motor run contacts to PLC / DCS. Similarly for Start & stop Commands from PLC, separate Multipair cables shall be laid. All these cables shall be laid in Electrical Cable Trench. RCC partition shall be provided in the Electrical cable trench for separation of these signals. Separate Junction boxes shall be considered for these signals & the same shall be provided at MCC end.

Electrical/instrumentation interface system to be submitted by LSTK for PMC/OWNER approval.

3.3.14 ILOAD REQUIREMENTS

3.3.14.1 The UPS load requirement for instrumentation shall be calculated by contractor considering:

a) UPS required for various systems like contractor supplied DCS, PLC, etc. located in the control room.

b) UPS requirement for the systems and instruments connected to DCS /PLC. (Systems mean Analysers system etc. which is in contractor’s scope).

c) UPS load requirement for the non-system loads like local panels, 3 wire/4 wire instruments etc.
d) Any other load indicated in this package or as required by the contractor.

3.3.14.2 A minimum 20% additional load shall be considered over and above the actual calculated load for sizing the UPS.

3.3.14.3 Contractor shall furnish the feeder details for the units in their scope.

3.3.14.4 110 V AC UPS feeders for the systems other than DCS and PLC shall be fully isolated using Isolation transformer.

3.3.14.5 For field non-DCS higher loads like analyzer, Special Instruments, separate feeder shall be provided in UPS ACDB.

3.3.14.6 Spare Feeder minimum of 10% or one of each rating and type shall be provided un the UPS Distribution box.

3.3.14.7 The size of Terminal shall be suitable for the size of the incoming cables.

4.0 JOB SPECIFICATION

4.1 GENERAL

This document defines the instrument job requirements over and above various Standards attached alongwith this document.

4.2 TECHNICAL SPECIFICATIONS

4.2.1 INSTRUMENTS

4.2.1.1 The selection of type of instruments is Contractor’s responsibility. For the instruments where type is already identified in the P & IDs / data sheets, the Contractor shall follow the same. However during the engineering / procurement stage if it is found that a different type of instrument is most suited for a particular application then the same shall be referred to Owner / PMC for review, and if suitable, the changed instrument shall be supplied by the contractor. Contractor shall also be responsible for selecting and reviewing the type of instrument where specifically indicated in P& ID.

b) Instrument selection and specifications shall be carried out as per Licensor requirements, Design requirements, and Standard Specification for Package units in general, as appended by special requirements specified here in.

c) Instruments/systems which are common for different process conditions shall be selected accordingly. Any hardware/ additional instrument required to meet the varying process condition (e.g. regeneration, turndown etc) shall be supplied by contractor. Any software additionally required in system such as Governor system, Antisurge controllers (if applicable) etc., shall be in contractor’s scope. Any updating of P&ID and other document to include above shall be contractors responsibility.
d) Field switches should not be used. Mechanical type of limit switch not to be used.

e) Any instrument specified as proprietary item by licensor in process packages shall be procured with same specifications and from same vendors as given in the process package.

f) Special treatment (e.g. silicon coating) shall be given to Threads & stem to avoid galling.

g) CONTRACTOR shall supply SS 316 flareless compression tube fitting of three-piece construction of Swagelok / Parker or equivalent make only. The tube fittings shall be of minimum 3000 LBS rating.

The fitting/ferrule hardness shall be in the range of RB 85-90 so as to ensure a minimum hardness difference of 5 to 10 between tube and fittings. The ferrule shall be of stainless steel material, in general.

Socket-weld type forged pipe fittings of suitable material and rating shall be supplied for pipe fittings. The minimum rating shall be 3000#. Weld neck fittings shall be used where socket weld types are not allowed by piping class.

All threaded fittings shall have NPT threads as per ANSI/ASME B16.11 only.

The CONTRACTOR as per spare parts list philosophy shall supply spares against all these items.

All the pipe fittings shall be of 3000# minimum rating.

All tubing shall be properly clamped as per international standard and good engineering practice.

i) For all analysers and other special instruments, contractor shall be responsible to provide services of manufacturer personnel during engineering, testing, loop checking, commissioning of system and plant. No alternate representation shall be acceptable in any case.

j) Contractor shall supply all instruments required for the advance control requirement and connecting these the DCS. However the implementation of the advanced control strategies in DCS or supervisory computer shall be carried out by client in future, unless specifically indicated in process package/P&ID or other documents attached.

k) The material of elastomers used in instruments shall be suitable for the specified service. Use of asbestos or asbestos bearing materials shall be avoided unless absolutely necessary. The type and material of Gaskets should be strictly as per piping specifications.

4.2.1.2 Field Transmitters

4.2.1.2.1 Contractor shall supply all transmitter of SMART type transmitters with HART protocol as per design basis unless there is any technological limitation (not any specific vendor portray limitation) or specifically specified otherwise. However for PLANT, Hart functionality shall be inhibited.

4.2.1.2.2 Accuracy of the pressure and differential type of transmitters (flow, DP type level, differential pressure, gauge and absolute pressure transmitter) shall be ± 0.075% of span or better within the rangeability of 1:10. This accuracy includes the combined effect of linearity, hysteresis and repeatability. Transmitter element material shall be minimum AISI SS 316. Accuracy for analogue transmitters(non-smart) type shall be ± 0.2% or better.
All smart transmitters shall have rangeability of 1:100. Transmitter with lower rangeability shall not be supplied.

The response time of diaphragm seal transmitter shall be of the order of 3 seconds but in no case shall exceed 5 seconds. The SS316 armoured capillary shall be with PVC covering over the armour.

Static pressure rating for all the transmitters should be of the order of 100 Kg/cm² for all applications in general. However contractor must ensure that static pressure shall not be less than 1.5 times of maximum operating pressure.

The contractor shall supply at least four number of universal type of hand held communicators, contractor shall supply a minimum of two chargers for charging hand held communicators.

Update rate of the SMART transmitters shall be in commensurate with the process. It shall be equal or better than half of the scan time of the control loop specified else where in this package.

The cables for smart transmitters shall be selected based on Hart maintenance system requirements.

The square root extraction for the differential pressure based flow measurement shall be carried out in DCS.

All the transmitters should have horizontal impulse entry only for easy interchangeability without impulse modification in future.

Temperature Instruments

All temperature elements shall be duplex type.

For transmission of individual temperature signals, thermocouples shall be used in conjunction with field mounted temperature transmitters.

Resistance Temperature element (RTD) may be used as temperature primary elements where greater accuracy and better reproducibility are required than is afforded by thermocouples. RTD shall conform to standard IEC-751.

All temperature elements shall generally be protected by thermo-wells. Class 'A' / Class ‘1’ tolerance as per IEC 751 / 584-2 shall be specified for RTD / thermocouple for temperature measurement used in closed loops, interlocks and monitoring of critical parameters.

Thermocouples:

Electrical properties and tolerances shall be as per IEC-584-2.

Thermocouples shall be spring loaded, magnesium oxide mineral-insulated metal sheathed with grounded tip. Other specification shall be as below:

- Wire size shall be 18 AWG for single and 20 AWG for Duplex type.
- Sheath material shall be in stainless steel 316.
- Outer diameter of sheath shall normally be 6.4 mm.
- 'K' / 'E' type thermocouple shall be used. (For measuring of low temperature 'E' type thermocouple shall be considered.)
- Thermocouple extension wire and calibration shall conform to ANSI MC 96.1.  
- Skin thermocouples shall generally be RETRACTO type of Geyesco design with material as per API unless specified otherwise in the licensor specification/Job specification.
- Heater skin thermocouple standard should be very carefully followed based on heater piping orientation.

- For heater thermocouples, mineral insulated Inconel-600 sheath shall be considered for Non-sulphurous atmosphere and SS-446 sheath shall be used for sulphurous services. Kanthal sheath material shall be used above 870 deg. C temperature.

Resistance temperature elements

- RTD shall conform to be PT-100, 3-wire type. Din 43760 standard
- RTD shall be spring-loaded, mineral insulated and SS 316 metal sheath type
- The sheath diameter shall be 6.4 mm as a standard unless otherwise specified.

RTD/Thermocouple heads shall be as follows:

- The thermocouple head shall be connected with thermowell with 3-piece union to ensure proper contact of TC junction to thermowell.
- Head cover shall be screwed type, with SS retaining Chain fixed to body.
- Head cover shall be weather proof and ex proof suitable to specified hazardous area classification.
- Cable entry shall be 2 nos. 1/2” NPT (F) with one entry plugged with SS 304 plug.
- Terminals shall have separate screws for connecting element and extension cable.
- All RTDs including for Bearing & winding temperature shall be 3 wire, Pt 100 to DIN 43760 standard. Special application thermocouple like Skin temperature measurement for heater or reactor etc shall comply with Licensor’s specification.

Temperature Switches shall not be used.

Temperature Transmitters

Temperature transmitter shall be provided for all temperature elements (i.e. for both open / closed and interlock loops).

Temperature transmitters shall be Remote mounted type (on 2” Pipe), Smart with HART protocol with integral output meter. Transmitter shall be dual compartment type.

Head mounted transmitters shall not be used.

Conventional transmitter shall have universal input for thermocouple / RTD and output 4-20mA DC for 2 wire system.

Transmitter output signal shall be linear and directly proportional to the measured temperature with overall accuracy of +/- 0.1% FS

Transmitter shall have automatic cold junction compensation for thermocouples.

Burnout protection (selectable Up Scale / Down Scale) must be provided for temperature transmitters.

Temperature transmitters shall be provided for all temperature elements.
Temperature transmitters shall be directly connected as analog input to DCS / PLC for monitoring, controlling & trips.

**Filled system / bimetallic element local gauges**

Gas filled gauges shall be considered. No mercury filled system to be used.

Filled system elements shall be as per gas-filled (as per SAMA) as required by temperature limit and span consideration.

(Explosive, flammable or toxic liquid/gas should not be used as the filling medium)

The thermal filled system shall be equipped with ambient temperature compensation, over range and/or under range protection. Accuracy shall be ± 1% of span.

Element bulb extension shall be with armoured capillary in 316 SS having capillary length of 3.5 meter minimum.

Thermal element bulb shall be protected in thermowell.

½” NPTM adjustable bush & gland of SS shall be provided on element bulb stem to maintain the firm insertion of the bulb in thermowell.

Filled system instruments shall not be used if process contamination due to system failure is not acceptable.

Dial size of the gauge shall be 150 mm diameter.

The stem and case material of the gauges shall be 316 SS.

Range shall be selected from manufacturer's standards such that normal operating temperature indication is approximately at midscale.

In vibrating services bimetallic thermometers shall not be used and only filled capillary type be used.

All temperature gauges are to be gas filled, every angle type and no mercury liquid filled type temperatures gauges are envisaged.

Temperature gauge casing shall be SS

**Special Thermometers**

Infrared radiation thermometer, thermistor sensor etc. shall be used based on the process requirement.

**Thermo-wells**

Thermo-wells shall generally be provided for protection of the primary measuring element.
Thermowell shall be designed to two-phase flow velocity. Vibration analysis test to be carried out for Thermowells to be used in high-pressure two-phase applications. Wake frequency calculation shall be done & the same to be submitted to PMC/OWNER for review.

Reformer Thermowell shall be as per licensor specification.

Thermowells for all services shall be in SS 316 minimum, and drilled in a single piece from solid bar stock and tapered.

Thermowells process connections shall be flanged 11/2" ANSI, 300# rating. Well and flange material shall be SS 316 minimum.

For sour services, thermowell material shall be as per PMS. All thermowell shall be flanged type only. Also all thermowells with rating 900# and above shall be RTJ type only

These shall be fabricated from bar-stock.

Immersion length of thermowells for different line sizes shall be as follows:-

<table>
<thead>
<tr>
<th>Line Size</th>
<th>Immersion length (U)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot; to 6&quot;</td>
<td>280 mm</td>
</tr>
<tr>
<td>8&quot; and above</td>
<td>320 mm</td>
</tr>
<tr>
<td>Vessels</td>
<td>400 mm</td>
</tr>
<tr>
<td>Flue Gas Tray</td>
<td>Minimum 120mm projection inside the tray after the tray insulation,</td>
</tr>
<tr>
<td>Heater Box</td>
<td>Minimum 120mm projection inside the tray after the tray insulation,</td>
</tr>
</tbody>
</table>

Immersion length is based on 200 mm length between flange face and inner well of pipe. In vessels, where fouling with vessel internals is expected, the immersion length shall be suitably modified. However licensors standards / recommendation shall be followed as governing case.

Other sizes and immersion lengths may be considered based on special condition / actual requirements.

Generally thermowell shall be drilled bar stock. Built-up thermowells may be considered in low pressure and low velocity services like in fired heaters and also where longer thermowell immersion length are required (for greater than or equal to 500 mm).

For Alloy steel piping classes, the thermowell and flange material shall be of SS321 / SS347 (no dissimilar welding).

The design of the wells shall be verified by means of stress analysis, resulting from stream velocity condition. The wake frequency shall not exceed 66% of the thermowell natural frequency.

Pipe line below 4" nominal bore shall be blown to 4" NB size to install thermowell.

Only thermowell (test well) when specified, it shall be provided the element entry plugged with SS plug and SS chain.

All the thermowells shall be offered for hydrotesting at site to PMC/OWNER before installation.

4.2.1.3.1 Thermocouple sheath material shall normally be SS 316 as a minimum. (Inconel 600 sheath shall be selected for temperatures greater than 600 C).
4.2.1.3.2  The gauge head of the Temperature elements (TIC, RTD’s) shall be 80 mm, as a minimum to ensure maintenance ease.

4.2.1.3.3  All held mounted temperature transmitters shall be remote mounted and shall meet the requirements specified in process package. The temperature transmitters except for those in anti-surge control loop shall be smart type. and shall provide ‘HART’ output.

4.2.1.3.4  Contractor to note that all thermowells except surface temperature instruments shall be of flanged type only.

4.2.1.3.5  Skin Thermocouple Assembly

a) The heater tube skin temperature or equipment wall skin temperature shall be measured using a well-proven skin thermocouple assembly design. Process licensor recommendation wherever provided, shall be followed in toto.

b) Manufacturer’s recommendations shall be followed for the installation, which shall take care of tube expansion and lateral movement. Enough expansion loops shall be provided. The entry point shall be suitably sealed with insulation like Rockwool to ensure unhindered movement.

4.2.1.3.7  Contractor must carryout vibration analysis for all thermowells and provide suitable design wherever analysis points toward fatigue failure. The vibration analysis calculations shall be forwarded to owner PMC for review.

4.2.1.3.8  Thermowells for High Temperature

a) The thermowells for main combustion chamber shall be provided with ceramic thermowells.

b) The thermowells shall be specifically designed to meet the severe service conditions as specified in the data-sheets.

c) The thermowells shall be handled with care and shall be installed only after the completion of the complete unit installation works. The location of installation shall be such that the thermowell is not subject to any mechanical vibrations or thermal shock.

d) The thermowells sheath shall be suitable for the chamber temperature. Unless otherwise specified in the data sheets, the sheath material shall be Incalloy 800 or Inconel 600.

4.2.1.4  Level Instruments

Level Transmitter

a) Guided wave radar type instruments (SMART) shall normally be used for level measurement up to 1219 mm, wherever guided wave radar cannot be used then only external displacer type transmitter to be used. Differential pressure transmitter (Capillary type) shall be used for level measurement above 1219 mm and for services requiring purge or where liquid might boil in external portion. Internal displacer type of level transmitters shall not be used.
b) All displacer type of level transmitters shall be of torque tube type with torque tube material of inconel, as a minimum.

c) Non-contact type level transmitters may be used on corrosive, congealing, slurry services where diaphragm seal type transmitter cannot be used.

d) For all other services except vacuum, DP type diaphragm seal (capillary) instrument shall be used except for H2 services. However, capillary length should be sufficient to install the transmitter below the lower tapping. In no cases the transmitter should be installed in between lower and upper tapping. Capillary length should be decided based on CC distance, required DP range and nearest best possible place for mounting the same taking into account all structural and approach to the instrument.

e) Radar type Level transmitter to be used in place of internal displacer type wherever service is of varying density.

f) Water cut measurement with radar is to be provided for tanks, Servo for local indication can be considered only if it is essential to install over and above the radar gauge.

g) Only ultrasonic or radar type level instruments are to be used for all acid and alkali tanks.

h) For sumps and tanks, Radar type level instruments shall be used.

i) For CBD applications non-contact type top mounted level measuring instruments like radar type shall be used.

j) The level tapping from the vessels & columns are not to be taken from bottom. The lower tapping is to be from side of the column / vessel. And accordingly minimum measurement level will be considered from the minimum possible level nozzle location. The standpipe from the tapping is to have a positive slope towards the tapping.

k) Level measurement for protray tanks, two level instruments shall be provided for each tank. Both level instruments shall be different type. In general one shall be radar type & other shall be servo type. As far as possible level measurement of process equipments guided wave process radar instrument shall be used in place of Displacer type of instrument.

4.2.1.4.1 Steam Drum Instrumentation

<table>
<thead>
<tr>
<th>Type of level instrument</th>
<th>Conductivity</th>
<th>DP</th>
<th>IBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety valves</td>
<td>Section I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level measurement</td>
<td>2 out of 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level gauges 2 Nos. (Bicolour)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hydra step level transmitter shall be provided in addition to this one extra GWR type level transmitter suitable for boiler application shall be provided in all steam drums.
Level transmitters used for drum level control shall not be used for rip application. 2oo3 voting logic shall be considered for trip application.

4.2.1.4.2 Level switches shall not be used as per plant philosophy, instead level transmitters shall only be provided.

4.2.1.4.3 For all the level tapings / standpipe tapings for all vessels, columns, tanks etc., free draining slope toward the vessel shall be provided.

4.2.1.4.4 All level gauges for plant shall be magnetic type except for steam drum, which shall be bicolor type.

4.2.1.4.5 Contractor shall be careful in selecting metallurgy of the instruments inline with guidelines provided in this section. However for hot and cold condensate separator, diaphragm/float material shall be tantalum as a minimum as has been recommended by licensor.

Level Gauge Glasses

All gauge glasses shall be generally steel armoured reflex or transparent type. Body material and cover material shall normally be forged carbon steel. 304 SS or other materials may be used, if required, by process conditions. Tempered borosilicate glass with asbestos or other gaskets shall be used. All gauge glasses must have a rating equal to or more than the vessel design pressure and temperature.

Reflex type will be used for clean and colourless liquids, except liquids level interface. Transparent type will be used on acid, caustic, dirty or viscous, coloured liquids and liquid interface.

Liquid level gauges shall be used for local indication. Gauge glasses shall be made of borosilicate armoured / toughened glass. Gauge glass shall be a single piece forged construction.

The transparent gauge glass shall be provided with protective shield.

In case of service of crystallizing and viscous fluids, need steam tracing at ambient temperature, level gauge shall be provided with facility of tracing.

The visible range of level gauge shall be selected to cover the operating level or the operating range of level instruments provided for the vessel.

The maximum visibility length of a single gauge shall not exceed 1500 mm. Normally glass of 300 mm (approx) section length shall be used.

On low temperature services with liquids having very high vapour pressure at ambient temperatures safety valves shall be provided on the vent connection of the gauge glass.

Frost protection shall be considered for minus temperature fluid application

Steam Drum Level Measurement

Hydra step or conductivity type measurement shall be provided for steam drum applications in addition to DP type level measurement and all other instruments, in addition to this one GWR type level transmitter suitable for Boiler application shall be provided in all steam drums/boilers.
4.2.1.4 Usage of standpipe criteria:

Level instrument and standpipe installation shall be as per requirements indicated in process package. However where no such requirements are indicated in process package, following may be adopted:

a) The usage of standpipe shall be considered for clean, non-viscous and non-crystallizing services. The size of standpipe shall be 2" NB, unless otherwise indicated by licensor’s in their process packages or shown in P&ID.

b) Standpipe shall be used if there are more than 4 nozzles required for level instruments e.g. one displacer instrument and one level gauge can be mounted directly on the equipment.

c) The maximum number of nozzles on the standpipe shall be limited as follows:

   i) To 8 with no displacer type level instrument on it.
   ii) To 6 with displacer type level instrument on it.

d) Connection of standpipe from the bottom of equipment shall not be considered.

e) The minimum readable liquid level from the bottom tangent line for level gauge with Top and Bottom connections and when both the nozzles of level gauge are from the equipment side shall be 300 mm with / without standpipe against 150mm for side-side connections.

f) Multiple gauges shall be used for visible lengths more than 1470 mm.

g) Separate standpipe to be used for boot interlace level measurement in addition to standpipe used for horizontal vessel. The intermediate connection from vessel to standpipe (third nozzle) shall be provided for interface measurement as required.

h) Where level gauges are to be used alongwith transmitter, the visible length of the level gauge shall be selected to cover the complete transmitter range.

4.2.1.5 Flow Instruments.

<table>
<thead>
<tr>
<th>Service</th>
<th>Tapping Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Transmitter</td>
<td>Two Transmitters</td>
</tr>
<tr>
<td>Liquid/ sour water</td>
<td>Horizontal</td>
</tr>
<tr>
<td>Gas/Air</td>
<td>Vertically up</td>
</tr>
<tr>
<td>Steam/ Utility water</td>
<td>Horizontal</td>
</tr>
</tbody>
</table>

A) The choice of primary differential producing devices will depend on service conditions and on the permanent pressure loss, which can be tolerated. A square edged concentric orifice plate is the usual selection if conditions
permit. Quadrant edge or quarter circle orifice plates shall be used for viscous liquids and for pipe Reynolds number below 10,000 Conical entrance type of orifice plates shall preferably be used for very highly viscous liquids upto throat Reynolds number of 250. These shall be fabricated as per ISO 5167. Vent and drain holes shall be provided wherever necessary.

The primary element shall generally be thin plate, square-edge concentric orifices plate mounted between a pair of weld-neck type orifice flanges with flange taps. The minimum pressure rating of flanges shall be as per PMS. Eccentric and Segmental type of orifice plates shall be used for specific application. Quadrant edge or conical entrance orifice plates shall be used for services with low Reynolds number.

In case of multi-transmitter installation from a single orifice, separate identical pair of tappings to be provided for the separate transmitters i.e. no branching from a single tapping. All tappings emerging from orifices shall be horizontal and shall have sufficient straight length in mass balance application or if specified by Licensors.

In case, three or more transmitters are provided on single orifice, individual tapping shall be considered with isolation for transmitters.

B) Coriolis mass flowmeters shall be used where greater accuracy is required like for custody transfer, blending, feed flow from battery limit, etc and for highly viscous and fouling fluids like fuel oil etc. In no case Turbine type or PD flow meter shall be used. Where Mass flow meter is not applicable Ultra sonic flow meter/Magnetic flow meter can be used. For the measurement of Cooling water flow magnetic flow meter shall be used in general.

For airflow measurements Venturi shall be used. Pitot tube is not acceptable.

Venturi and flow nozzles may be selected where system requires low-pressure drops.

Vortex meter shall be considered as per licensor recommendation.

Ultrasonic flow meter may be considered for the flow meter on large bore piping such as flare gas measurement.

Variable area flowmeters may be used where measurement with low accuracy is accepted.

Flow nozzles, venturies, target meters, magnetic flowmeters, Vortex, ultrasonic flowmeters, self averaging pitot tube etc may be used wherever specified in the data sheet or as required.

DP type flow transmitter shall normally be electronic SMART type with integral LCD indicator for output indication.

For cooling water supply & return flow measurement, magnetic flow meters should be used. Annubar should not be used in CW line. CW line should be above ground for instrument installation purposes.

No flow switches shall be used. The same shall be achieved through flow transmitters, which shall be directly connected as analog input to DCS/PLC.

No PD / Turbine meters shall be considered unless otherwise specified by Licensor. Only Mass flow meters shall be used instead of PD / Turbine meters.

Vortex flow meters shall be taken for high rangeability applications.

Eccentric and Segmental type of orifice plates shall be used for specific applications like highly viscous fluid etc.
Quadrant edge or conical entrance orifice plates shall be used for services with low Reynolds number.

Vent and Drain holes shall be provided wherever necessary.

For fuel oil service, coriolis mass flow meter shall be used.

For steam service above 16", flow nozzle can be provided.

For combustion air flow measurement in heaters, venturi to be used instead of annubar.

However, requirement of upstream and down stream straight length should be taken care by piping group and same should be offered for review during 3D review by Instrument personnel.

C) Thin Plate Orifices:

Orifice plate shall be thin plate with square-edge concentric orifice. The plate shall be mounted between a pair of weld-neck flanges with flange taps to form orifice plate assembly.

The following sizing principle shall be followed:

a) Maximum meter flow shall equal the nearest preferred factor greater than or equal to 1.43 x Normal flow, if only the normal flow is known. If maximum flow only is given, Maximum meter flow shall equal the nearest preferred factor greater than or equal to 1.1 maximum flow given. If a rangeability larger than 30% to 90% is required, two measuring instruments with different ranges may be considered.

Orifice diameters should be selected so that the d/D ratio is between 0.30 to 0.70 for gas and steam and upto 0.75 for liquids.

b) Orifice meter differential range, shall normally be 2500 mm H2O, dry calibration. Other preferred ranges will be 500 mm, 1250 mm, 5000 mm and 10,000 mm. For compressible fluids, the selected differential in inches of water shall not exceed the upstream static pressure in pound per square inch absolute.

c) Metering orifices shall not be installed in lines less than 1½” nominal diameter. If process lines are less than 1½” the lines shall be blown to the 1½” size for the meter run, keeping the d/D ratio within limits. When the meter runs cannot be blown to 1½” calibrated meter runs may be used. If d/D ratio exceeds 0.75 for 5000 mm differential range, then the process line shall be blown for the meter run.

- Design calculation of standard type orifice plates shall be as per ISO 5167.

The flow range shall be selected such that normal flow rates are between 50% and 70% of the flow upper range value.

Material of construction of orifice plate shall be 316 SS except where this material is unsuitable for the service because of corrosion or erosion considerations, in which case an alloy shall be chosen whose corrosion allowance is equal to or better than line material. Orifice plates dimensions, finishing, flatness, tolerances for dimensions and identification information shall be in accordance with ISO standard. Orifice plate shall be provided with tab handle, which is welded on the orifice plate and engraved with following information on the upstream of the tab handle:

- UPSTREAM or UP
- Instrument tag number
- Orifice diameter, Beta
- NPS (Nominal Pipe Size) and ANSI flange class
- Material of the orifice plate

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CONTRACTOR shall submit the sizing calculations for orifice plates to PMC for review.

D) Flange taps orifice shall generally be used for line sizes 2” to and including 14”. Above 14” line size, D and D/2 taps shall be used. Meter run shall be provided instead of Integral Orifice assembly.

Orifice assembly shall be provided with two sets of “Flange Taps” located in accordance with latest AGA standards. The orifice assembly shall be provided with jack screw for removal of orifice plate. In case of 2 out of 3 logic requirement, three transmitters shall be used. In such case six set of taps shall be provided in orifice assembly.

Instrument tapping connections shall be 1/2”NPT (F).

E) Orifice flanges

Orifice flanges shall be in accordance with the ANSI B16.36, ANSI B16.36a, IBR, Hydrogen service and sour water requirement, and applicable piping specification.

F) D/P Flow Transmitters

For congealing services, 3”diaphragm type DP transmitters shall be used.

Flow transmitters for use with differential producing devices shall be smart Transmitter with Universal HART protocol with Latest Revision with integral LCD indicator and be furnished with test terminals and bypass diode to facilitate field testing without disconnection of integral indicator. The transmitters shall have over-range protection.

Body pressure rating shall be 100 bar minimum and measuring capsules shall be able to withstand pressure up to the body rating in either direction without damaging the instrument or shifting the zero more than 0.5% of the span. The body and other wetted parts material shall be SS 316 minimum. Other materials such as hastelloy, Monel or tantalum may be used as per process requirement.

The transmitter electronics shall be capable of monitoring their performance during normal operation. The transmitter diagnostics shall be able to detect both an input sensor failure and transmitter electronics failure. The sensor &/or electronics failure shall be transmitted to the host system (e.g. DCS / PLC). The stability shall be better than +/- 0.5% of upper range limit for 10 year.

Process connections shall be 1/2” National Pipe Thread (NPTF) and from the side/horizontal to the transmitter. Cable entry shall be 1/2” (NPTF).

Three-valve/five valve manifold and oval flange adaptor shall be provided in place of isolation & equalizing valves in the impulse piping of flow transmitters for the service up to 600 # rating. However in case of high pressure service and any special requirement, piping manifold with single / double isolation valves and equalizing valve shall be considered.

All transmitters body material shall be SS material.

G) Rotameters

Rotameters may be required as indicators or transmitters. Accuracy of measurement shall be within 2% full scale. Rotameters shall be mounted in-line for pipe sizes less than 2 inches. Armoured glass / metal tube meters shall be
used on hydrocarbon (liquid or gas) service, steam or other hazardous application. Rotameter Rangeability shall be
more than 10:1. Flow damper shall be provided for pulsating flow. Cooling fins shall be provided for high
temperature service (150 deg C & above) & extension well shall be provided for low temperature service (0 deg C
and below). Jacket shall be provided for crystallizing fluid at ambient temperature. For critical rotameters, magnetic
filters shall be installed at the inlet of the meters.

Only metal tube Rotameter shall be considered. Glass tube Rotameter shall not be used.

H) Purgemeters

Purgemeter units shall consist of a glass / metal tube rotameter with needle valve at the inlet and a built-in check
valve at the outlet. A differential pressure regulator shall also be supplied in applications where either the purge
supply or process pressures are likely to vary significantly.

The design requirements for Purgemeters include: rangeability of 10:1, accuracy of +/-2% of maximum flow, “O”
ing ring construction, and end connections of 1/4” N.P.T (F).

4.2.1.5.1 Orifice meter with flange taps shall be selected in general with other type of flow meters and type of orifice
taps as specified in process package.

4.2.1.5.2 For orifice meters where the flow rangeability exceeds 4:1, dual/ multiple transmitters shall be used
irrespective whether same is shown in the P&I D’s or not.

4.2.1.5.3 All flow transmitters etc. shall be supplied alongwith integral manifolds and integral indicators, wherever
applicable.

4.2.1.5.4 For mass flow meters,. steam jacketing wherever required, shall be part of original instrument design and
shall be manufactured and tested at the manufacturer's works only. Cables from sensor and transmitter
shall be provided alongwith the instrument and flexible conduit, as necessary. The instrument shall have
terminals for each cable termination. Flying leads shall not be used. Contractor shall ensure that selected
mass flow meter has a valid statutory certification for hazardous area upto the maximum operating
temperature specified.

4.2.1.5.6 Contractor shall supply Flare flow meter of ultrasonic type, suitable for pipe mounting (not external clamp-
on type). The flow meter shall be complete with ultrasonic transducers with insert, retract mechanism with
full bore ball valve, preamplifier transmitter with transmitter console, special cabling etc. or any other item
required to make system complete. The interconnecting cable shall be armored type only. The
preamplifier/transmitter shall be microprocessor based field mounted certified flameproof for the area
classification. The transmitter console/display unit shall be provided for display of readings, configuration,
and calibration. The transmitter shall be capable of performing the pressure and temperature comparison
and hence mass flow calculations. Separate pressure (absolute) and temperature transmitters shall be
used for flow compensation irrespective of representation on P&ID. Additionally fault and flow alarm shall
be provided. The flow meter shall meet the following requirements:

Material of construction : SS 316 (Sensor1 Housing, Ball Valves)

Accuracy: Better than ± 5% of volumetric flow with no effect of
molecular weight variation on the accuracy
Repeatability : ± 1.0% of full range
Range ability: 1000:1
Output update: Better than once in 5 seconds.
Output: Isolated 4-20 mA for each volume flow rate, mass flow meter, molecular weight and velocity.

Contractor shall consider the straight length requirements while designing the system to meet the accuracy requirements.

### 4.2.1.5.7 Pressure Instruments

#### A) General

Gauge Pressure / DP transmitters shall be used for measurement & control of process pressure from DCS. Local indication shall be by means of pressure gauges (bourdon tube, diaphragm or other element) to suit the application.

#### B) Pressure Transmitters

All transmitters (including diaphragm seal) used in Hydrogen service shall be SS316 L Gold plated type.

No pressure switches shall be used. Instead pressure transmitters shall be considered which shall be directly connected as analog input to DCS/PLC. In case of DP applications in vessels & reactors, if the DP range is more than 1 KG/cm², two individual PT to be used in lower & upper level and DP to be calculated in DCS. This is to achieve better reliability and to avoid effect of accumulation of condensate in upper leg of DP transmitter

Pressure transmitters shall have suitable pressure sensing element and normally be with integral indicator.

The pressure transmitters shall have zero and range adjustable, and it shall be specified so that the normal operating pressure is within 40% to 70% of the calibrated range.

Overrange protection to 1.3 times the maximum range of the instrument shall be provided.

Transmitters in vacuum service shall be capable of withstanding full vacuum regardless of range, without damage or calibration shift.

Pressure transmitter process connections shall be 1/2” NPT (F).

The cable entry for transmitter shall be ½” NPT (F).

The body and wetted parts material shall normally be SS 316. Other element materials shall be based on process requirement.

Transmitter output, as specified, shall be linear, directly proportional to the applied pressure.

All transmitters shall be Smart type with HART protocol and with integral LCD indicator. Also transmitter shall have test terminals and bypass diode to facilitate field-testing without disconnection of integral indicator.

The stability shall be better than +/- 0.5% of upper range limit for 10 year.

Flush type diaphragm seal element with capillary shall be used for congealing, corrosive and highly viscous services. The extended capillary shall be minimum 3 meter long.

The process connection shall be flanged 3” ANSI RF.
The material for the diaphragm shall be as per process requirement, but minimum 316 SS

The flange material and rating shall be as per piping specification / SS-316 minimum.

C) Pressure Gauges

All gauges shall be provided with safety glass or shatterproof glass.

Local indication shall be by means of pressure gauges utilizing a bourdon tube, diaphragm or other element to suit the application.

Local pressure gauges shall have 150mm dials and shall be quality gauges designed for the process industry.

Ranges of gauges shall be selected such that the normal operating pressure indication is approximately at mid-scale.

Accuracy of local pressure gauges shall be +/-1.0% of full scale.

All pressure gauges in toxic service or with ranges 0 to 100 kg/cm² and above shall have safety type, solid front case.

In general for all transmitters like (Pressure, Flow) shall have an integral output meter with configurable LCD display with engineering unit, will be considered. It may be that in instruments, where configurable engineering unit display not available as standard, then the same to be considered as per standard available. Remote mounted meters may be provided for specific applications. However, same should not be put in series in the main loop. For realizing this requirement, single input & dual output barrier & AO Barrier shall be used.

Diaphragm seal element with capillary shall be used for congealing, corrosive and highly viscous services. Capillary shall be of minimum SS316 and shall have SS304 armouring with PVC covering.

No pressure switches shall be used. Instead pressure transmitters shall be considered which shall be directly connected as analog input to DCS/PLC. In case of DP applications in vessels & reactors, if the DP range is more than 1 KG/cm², two individual PT to be used in lower & upper level and DP to be calculated in DCS. This is to achieve better reliability and to avoid effect of accumulation of condensate in upper leg of DP transmitter.

Pressure gauges in pump discharge services are to be either with capillary diaphragm seal type or located in a remote location.

All pressure gauges shall have SS casing.

Pressure gauges shall be capable of withstanding intermittent overpressures of 1.3 times the maximum scale reading without damage or calibration shift of more than 1% of the scale reading. Blow out disc shall be provided for all ranges & solid front shall be provided for ranges above 100 Kg/cm².

Cases for gauges having ranges between 0-2 and 0-20 Kg/cm² shall have blowout discs in the back of the case.

Cases for gauges having ranges above 0-100 Kg/cm² shall be of the solid front type having blowout backs.

Gauges connections size shall be 1/2” NPT (M). Connection location shall be bottom for local mounting with wrench flats or back for local panel board with mounting flange.
All the gauges shall be equipped with 2 way valve manifold.

The standard measuring element shall be a bourdon tube of AISI 316 stainless steel, except where the process fluid requires the use of special material.

Bourdon tubes shall be welded to socket and tip and stress relieved as required.

Diaphragm type shall be used where necessary to protect gauges from corrosive fluid, crystallizing fluid, fluid including solids and high viscous fluid.

Diaphragm seals shall be of welded diaphragm type close coupled to the instrument, or connected to it with capillary tubing.

The connection size for diaphragm type gauge shall be 11/2” flanged. The diaphragm material shall be minimum 316 SS & flange material and rating shall be as per piping specification / minimum SS 316.

In case, the diaphragm seal type instrument with extended capillary is used extended capillary tube shall be armoured with stainless steel, and length shall be as determined individually but minimum 3 meter.

Diaphragm seals shall have flush connection 1/4” NPT with plug and filling connection.

For viscous fluids, the diaphragm seal shall be clean-out type with removable bottom case.

Sockets and tips shall be of the same material as the measuring element and shall be welded to the element using the same filler material. Movements shall be SS 304.

Dial face shall be white with black graduations marked. Also, the operating range shall be marked with ‘Green’ band and above range shall be marked with ‘Red’ band.

The gauge pointer shall be adjustable without removing it from its shaft. All pressure gauges shall be provided with block and bleed valves securely fastened with identification tags.

Pressure gauges in pump discharge services are to be either with capillary diaphragm seal type or located in a remote location.

Case shall be of stainless steel, solid front type and IP-65 minimum.

D) Auxiliary components for pressure gauge

Over range protector (gauge saver) shall be provided where a pressure gauge cannot withstand a protuberant pressure due to unavoidable operation. Over range protector whenever used shall be of SS316, as a minimum.

Pulsation dampener shall be provided for all pulsating services e.g. Reciprocating pump discharge piping etc. Pulsation dampeners shall be of minimum SS 316 and have connection 1/2” NPT (F) on both ends. Dampener shall be provided with integral screw head needle valve to adjust aperture externally.

Pigtail type siphon shall be provided for steam service. Siphons shall be made of minimum SS 316 having connections 1/2” NPT (M) on both ends.

E) Draft Gauges
In general, the draft gauges shall be provided for each process heater to measure draft at burners, and in the stack, if required by process. Direct connected gauges for indication of very low pressures and vacuum in the range of 0-0.5 m bar to 0-150 m bar shall be vertical scale gauges utilizing a slack diaphragm (rubberized nylon or equivalent) as the sensing element.

Draft gauges shall be designed for 2-inch pipe mounting.

Where draft gauges are for use in the field, a suitable housing shall be provided.

The design of the draft gauge shall incorporate linearizing linkages where necessary to ensure a linear response of the indicating pointer.

Draft gauges shall be required to have an accuracy of +/-3% FS or better and shall be capable of withstanding pressures or vacuum equivalent to 100% overrange.

Process connection shall be 1/4” NPT (F).

### 4.2.1.6 Control Valves

**General**

a) Control valves shall normally be Globe type single seated or double seated. For clean services, guiding shall be top and bottom/cage type. For highly viscous services, cage guiding shall be avoided. All control valves shall be with Leakage class IV as minimum for all types.

b) All shutdown valve tubing should be of 12 mm size in general.

c) Ball valves shall be considered for services where solids in suspension, high rangeability, low-pressure drops, and tight shut-off are required.

d) Triple offset Butterfly valves /Rotary type valves shall be considered for services where solids in suspension, low pressure drops and high capacities are required. All butterfly valves shall be triple offset type with leakage Class IV as minimum.

e) Angle valves shall be considered for services where flashing, coking, solids in suspension or very large pressure drops are encountered. Angle valves should be in general multistage plug type and not cage/channel stream type.

f) Smart positioners shall be provided with metallic casing/cover along with software for valve signature collection.

h) For steam / BFW application, body metallurgy of control valves shall be WC9 or F22 as minimum.

As a minimum, trim MOC shall be hardened stainless steel like 440 C, 17.4 PH. For BFW service control valves trim shall be SS316 with nitride/440C or better. Stellite is not recommended for BFW services.

For erosion service, high pressure drop, cavitating service hard surfacing of plug and seat material, stellite shall be used for all cases. Special cases valve may require 17.4PH seat and 440C solid plugs or other suitable material for severe services like steam etc.
i) Class VI leakage class with metal seat shall be considered for fuel gas services to flare below 200 deg C and/or 20 Kg/Cm² pressure drop. Above this pressure & temperature, leakage class V with metal-to-metal contact is to be considered.

j) Only SMART Positioners shall be used for all control valves and damper control. Usage of I/P converters shall be avoided. For high temperature services (Above 200 Deg C) remote feedback shall be used for the smart positioners.

k) All Solenoid valves shall be of SS body. All solenoid valves shall be either intrinsically safe type with 24VDC. It shall have integral terminal box. Flying leads are not acceptable. Solenoids shall be de-energized to trip. All the SOVs shall be direct operating type. Pilot operated SOVs shall be avoided. The trip SOVs shall be in redundant pairs and configured/connected for increased reliability.

l) The filter for AFR is to be 5 micron.

m) Block valve shall be line size and bypass valve control valve body size. Drain valve size shall be ¾” gate valve and provided with Blind flange.

n) All the shutdown valves shall be full port Ball type unless otherwise specified in the process package or P&ID. Other type of valve body shall be selected if ball type of shutdown valve can’t be used

A) Butterfly valves /Rotary eccentric type valves shall be considered for services where solids in suspension, low pressure drops and high capacities are required

B) Control Valve body shall be flange joint type.

C) Anti-cavitation trim shall be selected wherever cavitation is expected in the valve.

D) Sizing of control valves shall be as per ISA-S75-01. Also valve selection to be made for the manufacturer’s valve “CV” at maximum opening is not less than 160% of the CV calculated for normal design flow or 110% CV of maximum flow, whichever is higher.

Valve travel shall be between 20% to 70% for specified minimum & maximum flow.

Minimum body size of the control valve shall be 1” for all the line size. Reduced trim shall be considered for smaller line size / small flow.

CONTRACTOR shall submit the sizing calculations for all control valves in INTOOLS Package.

E) Valve Trim Characteristics
Equal percentage plugs shall normally be used when there are large variations in valve pressure drop.

Linear characteristic plug shall be selected for
   a) Level control
   b) Over pressure control in steam or gas service
   c) Small variations in valve pressure drop
   d) Operation by remote hand controller
   e) Split control and parallel control by two valves
   f) Small CV and low noise valves as designated by MFR.

Quick opening trim shall be used for ON-OFF and Emergency Shutdown Valves.

Material used for Trim shall be minimum 316 Stellite, with guide bushing of hardened stainless steel like 440 C, 17-4 PH all up to a pressure drop of 10 kg/cm. For higher pressure drops or erosive and slurry services and in general for all steam services, hardsurfacing of plug, seal rings and sealing area of inner valve with stellite shall be used.

Special cases may require 17-4 PH seat ring and 440 C solid plugs or other materials like Hastelloy, Monel etc.

Licensor requirements shall take precedence

F) Face to face dimensions of the control valves shall be as per ANSI/ISA-S75.03

G) Noise level measured at 1 metre downstream and 1 m upstream of pipe wall shall not exceed 85 dB. Source treatment of noise shall be preferred by using special trims like anti-noise trims.

H) Copper or copper alloys in valves and accessories shall be avoided.

I) Seat leakage shall be chosen in accordance with process demands, safe operation of the plant and shall conform to ANSI / FCI 70.2

J) Bonnet shall be provided with cooling fins or extension when the fluid temperature is 230 °C and more and shall be of extension type for low temperature -18 °C and below.

K) Flanged bolted type gland stuffing boxes shall be used. Packing shall normally be Teflon on liquid and gas service upto 200°C. Grafoil shall be used on steam service and temperature above 200°C.

L) Generally, control valve actuator shall be of the spring and diaphragm, pneumatically actuated type. Standard air control signal to positioner shall be 0.2 to 1.0 kg/cm2g. Piston type actuators with or without fail-safe capacity tanks shall be considered if actuator force requirements fall beyond the normal range of diaphragm actuators. All actuators shall be adequate to fully stroke the valve under the maximum differential pressure specified by the process requirements.

M) Smart positioners to be considered for all control valves. Air filter Regulator filter to be 5 micron. Miniature type, plastic body & drain assembly etc as parts of air filter regulator are not acceptable. For high temperature services (Above 200 Deg C) remote feedback shall be used for the smart positioners

N) E/P positioner shall be Smart type, operating on input signal 4-20 mA DC, and with HART protocol for diagnostic & remote calibration. Canopy shall be provided for E/P positioners and other accessories as required.
Partial Stroke testing shall be provided for ON / OFF valves using Smart Positioners for fail close valves. DCS AO (open loop) shall be used for realizing this partial stroke testing.

Partial Stroke Testing

Partial Stroke Testing (PST)
Partial stroke testing shall be performed to ensure satisfactory operation of on-off valve including all accessories on demand. The test shall be performed automatically by partially (around 10%) stroking the valve while these valves are in service. The test hardware and software shall meet the following minimum requirements;

a) Partial stroke test scheme shall be complete with all hardware and softwares which shall include solenoid valves, valve positioner and logic solver. All components used in PST shall be fail safe and shall not affect the on-off valve performance under any circumstances.

b) The PST design shall ensure;

i) The testing shall be carried out automatically at pre defined intervals which shall be adjustable.

ii) The shutdown demand shall always over-ride if PST is in operation at that time.

iii) The valve shall not operate beyond a predefined maximum allowable stroke valve under any condition or failure. When valve positioner is used to realise PST, the positioner output shall be limited beyond the allowable value in case of valve stuck condition.

iv) Audit trail shall be available to indicate time and date of PST, test results (OK / fail), reason of failure, changes made etc as a minimum.

v) Upward connectivity to purchaser’s Host system.

Vendor shall supply the complete testing assembly duly tubed / piped / wired on a SS mounting plate of thickness 3.2mm suitable for 2” pipe stanchion mounting. Standard pre designed rigidly mounted components shall also be acceptable for PST assembly.

O) Deleted

P) E/P Positioners, solenoid valves, booster relay, air lock relay, limit switches etc shall be supplied wherever required. Smart positioners shall be provided with metallic casing/cover along with software for valve signature collection.

Separate air filter regulator shall be used for each E/P Positioners.

Q) In general all tubing and fittings for control valve pneumatic signal shall be SS 304 minimum.
R) Hand wheel shall be considered where the block and by-pass valves are not provided in the process piping or when required by process. In general no by-pass or hand wheel shall be used for shutdown valves unless otherwise specified by licensor.

S) Limit switches (Proximity type) and any other electrical accessories shall conform to the electrical area classification and environmental conditions.

T) Limit switches shall be of Proximity type and intrinsically safe certified. Limit switches shall be provided both for close and open positions for all shutdown valves.

U) SIL3 certified 2oo3 Solenoid valves (Direct acting type) with plunger feedback shall be used as the pilot valve to trip a critical shutdown valve, Redundant SOV shall be used for non critical trip valve. Solenoid valves, wherever used, shall be universal type and shall be continuous rated type with class H coil insulation as per IEC 85/IS 1271. Ingress protection shall be IP67. All SOVs shall be SIL 3 certified.

Solenoid valve shall be of SS body with SS316 trim, as a minimum. Field manual reset shall be provided as per P&ID.

The solenoid valve operating voltage shall be 24 V DC and IS (intrinsic safe). For SOV with Field Manual Reset, the same shall be tamperproof manual reset type else SS illuminated ex-proof PB station shall be provided in field.

Direct line mounted SOV shall not be considered.

W) Seat leakage class for single ported and double ported valves or cage-guided valves shall be minimum class IV type. All tight shut-off valves specified by Licensor shall meet class V seat leakage class requirements for metal-seated valves and class VI requirements for soft-seated valves as per FCI 70-2.

Class-VI leakage class with soft seat shall be considered for fuel gas service to flare below 150° C and/or below 20-kg/cm2-pressure drop, other than this metal-to-metal contact with leakage class-V to be used.

X) The other auxiliary devices such as lock up relay, pilot relay, booster relay volume tank etc. shall be provided as parts of the actuating system in order to achieve the required stroke-speed, fail safe action etc. Instrument Air volume tank shall be of SS material of construction. Air reservoir shall be sized to maintain the valve open for 30 minutes of instrument air failure.

Y) All control valves in service for temperature less than –20 deg.C, shall undergo cryogenic testing in line with BS-6364.

Z) Deleted

Z1) Deleted

Z2) Class VI leakage class with soft seat shall be considered for fuel gas services to flare below 200 deg C and/or 20 Kg/Cm2 pressure drop. Above this pressure & temperature, leakage class V with metal-to-metal contact is to be considered.
Z3) Actuators
   a) Diaphragm actuators shall generally be used with 0.2 - 1.0 kg/cm²g spring range. For larger dP shut offs, higher spring range/higher areas shall be considered.
   b) Piston actuators can be considered for high-pressure drop services.
   d) Control valve / on-off valve, pneumatic valve shall be designed for minimum 4Kg/cm² air pressure.
   e) Valve actuators shall be designed with 1.5 times factor of safety.

Z4) All limit switches shall be proximity type only including the packages

4.6.1.6.3 All control and shutdown valves shall have flanged body. Welded type control valves shall not be used for any service, unless otherwise indicated by the licensor in process package.

4.2.1.6.4 For all valves with temperatures above 200 ºC, valve bonnets shall be with radiation fins / extension bonnets. This temperature limit shall be followed irrespective of any manufacturer claim of suitability of standard valve upto higher temperatures.

4.2.1.6.5 For all control valves, the trim characteristics shall be Equal Percentage except for high noise, cavitating or extremely low flow application where parabolic/modified =% shall be used. However for valves in open-close service, the trim inherent characteristic shall be On-Off.

4.2.1.6.6 The type of control valve body shall be selected by the contractor as per process package/P&ID. Contractor shall, in any case, be responsible for the correct selection based on the application and process data.

4.2.1.6.7 All the shutdown valves shall be full port Ball type unless otherwise specified in the process package or P&ID. Other type of valve body shall be selected if ball type of shutdown valve can't be used. Wherever timing requirements are specified by licensors for shutdown valves contractor shall meet the same and take approval from owner for the hook up arrangement of such tags.

4.2.1.6.8 Wherever shutdown valves have been specified as ‘Fire-proofed’ both valve body as well as valve actuator shall have fire proofing meeting requirements of API-607. For actuator where no testing standard exists, the testing requirements specified in API-607 for valve shall also be applicable for valve actuator.

4.2.1.6.9 Wherever contractor shutdown valves are installed in vacuum service or are likely to experience vacuum, the valve gland design shall be suitable for such a service.

4.2.1.6.10 For split range application, independent manipulated signal shall be used for each split range valve (i.e. use separate controller and Smart positioner for each valve).

4.2.1.6.11 Contractor to note that for the control valve actuator-coloring scheme shall be as follows:

   Direct Acting (Open on Air failure) valves : - Green.
   Reverse Acting (Close on Air failure) valves - Red

   Also all the control valve shall be tagged by fixing Acrylic tag plate.
4.2.1.6.12 In case multiple valves are required to be installed because of controllability or rangeability requirement, the same shall be provided by contractor irrespective of representation shown in the P&ID.

4.2.1.7 Pressure Relief Valves / Safety Valves

A.1 Sizing of safety relief valves shall be in accordance with API RP-520 (latest edition), Indian Boiler Regulations ASME Section I (Power Boilers) and ASME code for Pressure Vessels Section VIII'. The code stamps shall be provided for safety valves in case ASME and Indian Boiler Regulations design.

Safety relief valves shall normally be direct spring loaded types and provided with full nozzle type. Balanced bellows type safety valves shall be provided when variable backpressure exceeds 10% of the set pressure or fluid is corrosive. Pilot operated pressure relief valves shall be used for special services and where set pressure is closer than 10% of the operating pressure, in general. Thermal relief type valves shall be used for thermal expansion of liquid or gas. Vacuum relief type valves shall be used for Storage tank. Steam jacket type safety valves shall be used for crystallizing fluid at ambient temperature.

A.2 Thermal relief valves shall be flanged with Inlet 1” 600# RF and outlet 2” 150# RF with typical “D” designation and typically 0.38 cm² orifice size.

A.3 The body material shall, as a minimum, be as per piping specifications. Nozzle and disc material shall be SS316 as a minimum with machined stainless steel guide, and spindle. Whenever semi nozzle designs are unavoidable, body material shall be atleast same as nozzle material.

11.4 The spring material of pressure relief valves shall be as follows unless otherwise necessary because of process conditions.

-29°C to 250°C : Cadmium/nickel plated carbon steel
Above 250°C : Tungsten alloy steel
Below – 29°C : Stainless steel 316

A.5 Flanged connection shall normally be specified

A.7 Conventional type safety valves shall have vented bonnets with screwed caps; balanced bellows type safety valves shall be of the yoke type with screw setted caps.

A.8 Plain lifting levers shall be provided for steam and air services. Packed lifting levers shall be used when protection against leakage is required.

A.9 CONTRACTOR shall submit calculations for all safety relief valves.

A.10 All safety relief valves relieving to flare header shall be balanced bellows type only with trims and bellows in SS 316 L.

A.11 Pressure relief valves required for liquid service shall have liquid trim with discharge coefficient certified by ASME.

A.12 Pressure relief valve body casting and nozzle casting with inlet rating of 600 # and above in Hydrogen service shall undergo Helium leak test.
4.2.1.8 Pressure Reducing and Desuperheater Station

4.2.1.8.1 Desuperheater specification shall be as per requirements specified elsewhere and other specifications as specified elsewhere in this package. Wherever pressure reduction is also required along with Desuperheater, PRDS design shall be with separate pressure reduction valve and separate temperature valve. Integral PRDS are not acceptable. The valve shall be specially designed for high differential pressure, high temperature and high pressure steam application. This should also be ensured in case of Desuperheater design.

4.2.1.8.2 Desuperheater design should ensure that the temperature at the outlet shall be maintained within ±5 deg. C of the desired outlet temperature, unless otherwise specified by the process licensor.

4.2.1.8.3 Separate liquid injection valve and steam valves, if provided, must be installed along with block and bypass valve.

4.2.1.8.4 The body and trim material of construction shall be suitable for the service. In general trim including spray nozzles shall be STELLITED.

4.2.1.8.5 The PRDS/DSC in steam application including valve in Boiler Feed Water line shall be IBR certified.

A.1 Desuperheater design shall ensure that temperature at the outlet shall be maintained with +/-5 deg. C of desired outlet temperature, unless otherwise specified by the Licensor.

A.2 Separate liquid injection valve and steam valve, if provided must be installed along with block and bypass valve.

A.3 The body and trim material of construction shall be suitable for the service. In general trim including spray nozzle shall be stellited.

A.4 The PRDS/DSC in steam application shall be IBR certified including valve in boiler feed water line.

A.5 The CV shall be calculated in accordance with manufacturer’s calculation procedure and selected based on following points:

- Valve sizing shall be based on the maximum capacity of 1.25 times the normal flow or 1.1 times the max. Flow, whichever is greater.
- The minimum flow capacity shall be suitable for rangability of 30:1. The valve stroke shall not be less than 20% opening at the minimum flow capacity.
- Fluid velocity at the outlet shall be selected suitably in consideration of the property of fluid, the differential pressure of the valve and the line size etc.
- Noise level at 1 meter down stream of DS and at distance of 1 meter from the pipe surface at normal flow shall not exceed 85 DBA.

A.6 A manual operator, limit switch, solenoid valve or any other auxiliary devices shall be provided.

A.7 Mfr. Standard manual operator / Hand wheel shall be provided.

A.8 Direction of flow shall be permanently affixed on DS body.
4.2.1.9 Rupture Disc

A.1 CONTRACTOR shall provide rupture disc assembly wherever shown in P&ID. The assembly shall consist of:

A) The rupture disc fitted in a pre torqued holder assembly.
B) J bolt for proper installation
C) The Rupture disc experiences vacuum, shall be provided with vacuum support as recommended by manufacturers.

Disc material shall be compatible with the vessel contents and shall be consistent with the bursting requirements. Inconel discs shall be used above 100ºC if compatible with the process fluid.

A.2 When rupture disc is used upstream of a pressure relief valve, a pressure gauge, pressure switch and excess flow check valve / safety relief valve as recommended by manufacturers. (Tell-tale assembly) shall be provided on the downstream of the disc to indicate any rupture of the disc. In addition derating capacity factor for the safety valve – rupture disc assembly as recommended by ASME section VIII shall apply. Tell –tale assembly as above must be provided irrespective of P&ID representation. For plugging toxic service pressure gauges shall be diaphragm seal type.

A.3 Each rupture disc must be supplied with minimum 3 number of additional discs. This is in addition to discs required for carrying out burst testing at factory.

A.4 The indication of leaky rupture disc (i.e. the disc with a pen hole) or burst rupture disc shall be provided in the main control room.

A.5 The bursting tolerance of the rupture disc shall be ±5% of the specified bursting pressure or less. Unless otherwise specified.

4.2.1.10 CABLE TRAYS

a) Cable trays shall be perforated aluminum material.

b) All branch cables/tubes shall be run on cable trays. These cable trays shall be perforated type made of galvanized mild steel sheets of 2.0 mm thickness as a minimum.

c) Cables shall be laid over ground on racks or sleepers except for exceptional cases, where underground cabling required.

d) Cable trayroute should be away from hot pumps.

e) Cable tray laying to take care of the necessary clearances for fire proofing of structures.

g) Optical fiber cables and other communication cables pertaining to Machine monitoring system / analyser systems etc. shall be armoured.
4.2.1.11 EARTH PITS

Separate earth pits shall be provided for system earth, IS earth, power earth, and general body earth for instruments, equipments, junction box body etc. These earth pits shall be separate and isolated from electrical earth pits. Earth pit resistance and exact no earth pits/electrodes shall be considered based on the DCS/PLC & other instrument's manufactur's requirements and recommendation. For system earth redundant earth pit shall be provided. Both earth pit shall be connected to form ring loop. Earth resistance shall be decided in consultation with DCS/PLC vendor.

4.2.2 SYSTEM ORIENTED ITEMS

a) All units of LSTK package shall utilize the following control systems;
   i) Unit regulatory Control- DISTRIBUTED DIGITAL CONTROL AND MANAGEMENT INFORMATION SYSTEM (DCS)
   ii) Unit shutdown and interlock system- Programmable Logic controller (SIL3 certified)
   iii) Sub-Package Unit interlock & shutdown system (SIL 3 certified)- Unit programmable logic controller unless dedicated recommended by sub-package supplier.

c) For contractor supplied system/PLC all system cabinets especially those with electronic modules power supplies shall have enough number of cooling fans and ventilation louvers. In case of failure of any fan, contact shall be provided by contractor for generating alarm on DCS. In addition, all cabinets shall have temperature sensors for monitoring & alarm in DCS.

d) The minimum specifications of the DISTRIBUTED DIGITAL CONTROL AND MANAGEMENT INFORMATION SYSTEM (DCS) and programmable logic controller being procured by Contractor as given in the following clauses. In case, any additional feature is absolutely necessary for the proper unit operation, contractor shall supply necessary hardware & software to meet the system functional requirement without any cost & time implication.

PROVEN TRACK RECORD

LSTK contractor as offered / selected all instrument & accessories shall be field proven and should have been operating satisfactory for a minimum period of 2 Years. As on bid due in similar process condition in a Refinery / fertilizer. Items with prototype designs or items not meeting provenness criteria specified above shall not be offered.

The following information shall be furnished as a minimum along with their offer to support the proveness of the instruments being offered by them.

- Name of the Plant and Customer
- Model No. of the supplied Instrument
- Year of supply and commissioning
- Name, address, telephone/ fax no., e-mail of the contact person
- Application details

For DCS / PLC system the proven record must be available for the selected console / controller combination as a minimum.
The proven track record shall be as typical formats attached in Sample PTR Formats
4.2.2.1 Specific Requirements to DCS& PLC package.

The Special instruction shall read in conjunction with Design Philosophy requirement DCS / PLC Data Sheet and Job standard specification for DCS, design other specifications and other requirement shall be complied.

In case of conflict, the data sheets and this SIV shall override in general, however it shall be obligatory on the contractor's part to bring to the notice of the purchaser all such conflicts, wherein the PMC/OWNERS decision shall be final.

SPECIAL INSTRUCTIONS

4.2.2.1.1 Contractor to note that they shall be fully responsible for the Bill of Material submitted by them to meet all hardware and functional requirements as indicated in tender document. In addition, contractor shall be fully responsible for the total scope of work indicated in the document on turnkey basis and meeting all functional requirements through hardware and software during detail engineering.

4.2.2.1.2 In case of conflicts with respect to specifications, datasheet and any other engineering requirement or legal regulations, the contractor shall consider the most stringent requirement by default while selecting the DCS and PLC system.

4.2.2.1.3 System Modification / Change Management.

a) Contractor shall carry out all the modifications/changes/revisions necessary to be incorporated and pointed out at the time of FAT including graphic changes, wiring changes, I/O assignments, logic changes etc.

b) Contractor shall carry out all changes/modifications/revisions which are to be carried out during installation including additional inputs for sub-package items, configuration of new tags, termination changes, incorporation of cable schedule connections, modification and addition of new graphics, modification of group trend history etc.

c) Contractor shall carry out any changes required during loop checking and pre commissioning activities such as range change, graphic display changes, d) reassignment of I/O, termination changes etc. shall be performed by contractor.

e) Contractor shall carry out changes/modifications required in the system during commissioning and start up due to operational requirements like graphic changes, tag reassignment, tags new assignment, history trend and grouping, format changes, set point range changes, logic modifications etc. Contractor scope shall include incorporation of all such software/hardware configuration, engineering changes that may occur for normal engineering project execution.

f) Any changes mentioned in (a) to (e) shall be carried by Contractor on Free of Cost basis.

4.2.2.1.4 Contractor to note that Purchaser reserve the right to associate their personnel at any or all stages of project execution. Further, contractor shall not proceed without getting prior approval from purchaser for the documents required to be approved under "Contractor Data Requirement".

4.2.2.1.5 The storage of items / equipment at site shall be contractor's responsibility for all the items / equipments supplied by them. Handling of material at site is contractor's responsibility.

4.2.2.1.6 -
4.2.2.1.7 The loop checking shall be carried out in co-ordination with site Contractors, package contractors, purchaser / Field Contractors in accordance with Job standard specification for DCS and the requirements given in this document. It is essential that dedicated team of skilled personnel from contractors side shall be provided at site for each package item so that the execution activities such as installation, loop checking, commissioning, SAT are independently and conveniently done as required.

4.2.2.1.8 Power supply:

4.2.2.1.8.1 115 VAC UPS

115 VAC UPS systems shall be provided for New PLANT units by contractor as per specification the Electrical part of this document.

i. One 115 VAC UPS for EACHPLANT in Control Room UPS Room. Supply and laying of all necessary power supply cables is in contractor scope.

ii. For Non-DCS loads, major loads above 1.5 KVA, the feeder shall be provided from UPS AC Distribution Board (UPS ACDB) located at UPS room.

iii. For smaller loads, the distribution shall be provided from power supply distribution cabinet (by contractor) in Rack rooms.

iv. UPS feeders from ACDB to DCS loads shall be redundant whereas UPS feeders for Non-DCS loads shall Non-redundant.

v. No automatic sequential start-up is required for any power supply.

vi. The Contractor shall prepare a list Non-DCS UPS load requirement.

vii. 20% or minimum one no. Spare feeder shall be provided by the contractor for each feeder rating.

viii. The Size of UPS shall be arrived at after considering system and user loads. The system load shall be calculated considering:

   a) Expandability of I/Os including installed spares and installed future spare space.

   b) In rush current and PF for system/user load shall be considered.

The UPS sizing shall be arrived at after considering additional 10% capacity over and above the total of both system and user load.

4.2.2.1.8.2 230V AC:

The contractor shall provide 230V AC feeders with power distribution cabinet at for the 230V AC power supply for cabinet / Panel lighting, utility sockets and fans other load requirement.

4.2.2.1.8.3 24 VDC

i) 24 VDC power supply required for interrogation voltage, solenoid valve supply, lamp, pushbutton, etc and for other packages shall be supplied by contractor using dual redundant Bulk Power Supply (BPS).

ii) Each redundant bulk power supply shall be sized for 35% loading of its capacity in normal time; the maximum loading is to be 70% of its capacity of BPS.

iii) All bulk power supply (BPS) shall be provided with surge protection capability. BPS shall also provide with cooling fans and with fan failure alarm indications in DCS.

4.2.2.1.9 The system Power cables from PDB at rack room to DCS contractor supply items including cabinets etc. within control room shall be of copper only and shall be supplied by Contractor. The supply and laying of all incoming and pout going cables is in contractor scope.

4.2.2.1.10 110 VAC UPS Power supply feeder failure alarm before PDB shall be provided in DCS by using double pole MCB in PDB. One contact of these MCBs shall be wired to DCS for alarm purpose.
4.2.2.1.11 Fan failure alarm shall be provided in DCS for each cabinet.

4.2.2.1.12 Separate PDB cabinet shall be provided for primary & Redundant feeders.

4.2.2.1.13 The power distribution schemes shall be submitted for review and approval by PMC / Owner.

4.2.2.1.14 **Specific requirements for DCS/PLC:**

4.2.2.1.14.1 The PLC system shall be Tripple Modular redundant (TMR) or Quadruplicated Modular redundant (QMR) SIL-3, TUV certified PLC as a minimum.

4.2.2.1.14.2 The PLC for each unit shall be sized considering I/Os and other sizing requirements like scan time, CPU loading etc as per PR. The sizing calculations shall be reviewed during detail engineering. Contractor shall be fully responsible to supply number of PLCs as required meeting above requirements and approved sizing calculations.

4.2.2.1.14.3 The main PLC processor and I/O cards replacement should be possible on line without compromising the plant safety and TUV guidelines. The PLC system shall have high availability.

4.2.2.1.14.4 In case of two out of three voting inputs in PLC, the inputs shall be wired in three different cards.

4.2.2.1.14.5 Online programming changes shall be possible in PLC without requiring cold start. Further PLC Processor shall be Hot standby **(all time available)**. The communication between DCS and ESD PLC shall be less than 500 msec.

4.2.2.1.14.6 PLC shall be TUV AK5/SIL3 as per IEC 61508 certified and copy of certification shall be enclosed.

4.2.2.1.14.7 **PLC Console**

Each PLC system must be provided with PLC console at console area in control room for each unit and a programming & maintenance terminal PC (of latest version available at the time of supply) with printer in engineering room.

The programming terminal shall not be online under normal operating conditions (either powered off or have multiple password protection). Printer provided with programming terminal shall be able to print alarms (system and process) and documentation.

The PLC console shall be located along with operator console and shall be used by the operator for monitoring, issuing commands, maintenance override etc. The PLC console shall have full graphic capability and shall display shutdown and interlock graphic of the unit and it shall meet the requirement specified in Job standard specification for DCS.

The functionality of PLC engineering stations shall be as per specification.

4.2.2.1.14.7.1 SOE Recording with resolution of 1msec scan time shall be provided as inbuilt feature of PLC. At least 96 hours history for sequence of events should be available in PLC PC/ loader hard disk with LIFO facility. The SOE A&E printer shall automatically be updated on SOE PC as and when they occur and shall have automatic periodic archive and retrieval facility to prevent database overflow errors.

4.2.2.1.14.7.2 All PLC I/O signals shall be two wired, with no looping or common sharing of power supply or negative points as specified in the Job standard specification for DCS.
4.2.2.14.7.3 Maintenance over ride switches (software switches) shall be implemented from PLC console.

4.2.2.14.8 Interposing relays, Power Supply unit for TUV, SIL-3 Certified PLC shall be TUV, SIL-3 certified. However for IS barriers for PLC, both SIL-3 and SIL-2 certified barriers are acceptable.

4.2.2.14.9 Instrumentation shutdown and interlock shall be de-energizing to trip.

4.2.2.14.10 All Intrinsically safe DI / DOs shall be provided with barrier. All MCC Digital inputs / output, Field input / output (Non IS, if any) shall be connected through external interposing relay.

4.2.2.14.11 Hardwired switches, pushbuttons, lamps in Aux. Consoles shall be powered in 24 VDC circuit through external relays.

4.2.2.14.12 Contractor to note that the operator keyboard shall be membrane type. Each keyboard either integral or as a separate attachment shall have a set of dual function user configurable keys. 64 nos. of such functional keys are required and the same shall be provided in either of the following ways:

1. 64 hard keys.
2. Minimum 32 hard keys with balance functions provided as soft keys.

However when soft keys as per the point no. 2 above are provided for the balance 32 nos., the following condition shall be met:

For soft keys, key graphic display to be available to operator all the time without occupying the operator area of display.

These 64 nos. functional keys shall be configured to access important pages in single keystroke. These keys shall have LEDs which flash on preconfigured alarm conditions. However LEDs on hard keys which flash on pre-configured alarm conditions can be realised in DCS monitor as a soft display. These requirements supersede the requirement specified in Job standard specification for DISTRIBUTED DIGITAL CONTROL AND MANAGEMENT INFORMATION SYSTEM (DCS)

4.2.2.14.13 Contractor shall provide touch screen facility for the bottom tier TFT monitor of the dual tier operator console. Touch screen facility shall also be provided for Engineering station as well as Operator cum engineering station.

IAMS System shall be considered and provided by contractor for all analog(SMART) signals to DCS and PLC as per standard specification. All Field signals to DCS and PLC shall be SMART type with HART protocol. The I/O cards for DCS shall be HART protocol compatible. IAMS system shall include the following function:

- Interface with control and shutdown systems field devices.
- Record and compare valve signatures / operation.
- Log and interface with any partial valve stroke test systems used in the shutdown system.
• Maintain instrument test records
• Interfaces with other systems to enable integration into the overall AIMS.
• All maintenance related data like diagnostics alarms, transmitter range, settings etc.
• Trend data for all devices.
• Facility to re-range, configure and calibrate HART devices remotely.
• An audit trail for a complete historical record of all configuration, calibration and device alerts.
• Data on predictive maintenance such as list of transmitters experiencing drift, control valve losing as-shipped characteristics etc.
• Consider 1.4 times the maximum number of tag data for sizing.

Instrument Asset Management System shall facilitate the maintenance management of all smart and conventional field instruments. Unless otherwise specified, the system shall manage the maintenance of following:

• All smart instruments connected to Distributed Control System or Programmable Logic Controller.
• Non-smart / conventional and field instruments like local gauge cannot be connected to IAMS.
• All necessary DD/DTM files to connect IAMS with supplied smart instrumentation shall be supplied along with IAMS software.

Where ever HART pass through cards are considered IAMS shall be integrated, However if cards are not considered separate HART mux shall be provided. The VDU shall be 24" color TFT LED touch monitor along with a keyboard and a printer. The system shall support multiple authorization levels for carrying out configuration charges and calibration adjustment.

The Instrument Asset Management System shall meet the following requirements:

**Instrument Configuration**

It shall be possible to configure, verify the configured parameters, reconfigure, re-range and calibrate / recalibrate the smart devices from IAMS console.

**Device Status Monitoring**

The system shall monitor the status of all field devices and shall report any maintenance alarm generated by these devices. In general, following shall apply;

- Diagnostic alarms from smart devices in device failure and device diagnostic categories.
- Out of limit alarm shall be generated to indicate device failure alarm for conventional devices.

The system shall be capable of displaying and generating maintenance report listing all devices currently under alarm. The report may be generated unit-wise / area-wise or for complete plant.
Maintenance database
The system shall be able to maintain maintenance database for all the instruments which shall include date of commissioning, last calibration date, next due calibration. The system software shall have capability to manage and track scheduling of all such maintenance related activities. The software shall also provide data as predictive maintenance such as list of transmitter's experiences excessive drift, list of control valves loosing on shipping characteristics etc.

Audit Trail
The system shall have capability to provide an audit trail for a complete historical record of all configuration, calibration and device alert data. This shall include tracking of maintenance history for all instruments in the plant, typically recording the type of maintenance work done, smart and compiliation times of activity, person responsible for the activity etc.

Partial stoke testing shall be provided for ESD valves.
Partial Stroke testing shall be provided for ON / OFF valves using Smart Positioners for fail close valves. DCS AO (open loop) shall be used for realizing this partial stroke testing.

Partial Stroke Testing
Partial Stroke Testing shall be performed to ensure satisfactory operation of on-off valve including all accessories on demand. The test shall be performed automatically by partially (around 10%) stroking the valve while these valves are in service. The test hardware and software shall meet the following minimum requirements;

- Partial stroke test shall be complete with all hardware and software which shall include solenoid valves, valve positioner and logic solver. All components used in PST shall be failsafe and shall not affect the on-off valve performance under any circumstances.
- IAMS shall be provided with time stamping from GPS.

The PST design shall ensure;
1. The testing shall be carried out automatically at pre-defined intervals which shall be adjustable.
2. The valve shall not operate beyond a predefined maximum allowable stroke valve under any condition or failure. When valve positioner is used to realize PST, the positioner output shall be limited beyond the allowable value in case of valve stuck condition.
3. Audit trail shall be available to indicate time and date of PST, test results (OK / fail), reason of failure, changes made etc. as a minimum.
4. Upward connectivity to Purchaser’s Host system.

The SOV's of all critical valves should have 2oo3 operating mechanisms, with online coil changeover facility, partial stroke testing & plunger feedback which must be wired in the relevant DCS / ESD / Vendor Packages.
For rotating equipment such as turbines, 2oo3 mechanism for solenoid valve with online coil changeover facility may not be feasible due to space constraints. Valve vendor shall provide Factory Valve Signature Test Report in the form of hard copy and softcopy for each control valve provided with smart positioners. (Soft copy of native files shall be provided). Valve Vender shall supply valve signature software for all control valves and same shall be installed in IAMS.

**Advanced diagnostics**

The system shall be able to provide advanced diagnostics such as device step response, device signature, and dynamic error band etc. special device diagnostic software whenever required shall run in the system.

**Documentation**

System shall generate documentation like trend reports, diagnostic reports, pre-detectivemaintenance report, audit report, historical data and device specification sheet etc. Definition, engineering, configuration, loading and completion of all reports whether specificallyindicated are available as standard and shall be supplied as part of Vendor scope of supply

4.2.2.1.14.14 For PLC analog inputs only, if HART pass through card is not available as standard from the PLC manufacturer, bidder shall provide necessary HART multiplexer, as required, for communicating to IAMS.

4.2.2.1.14.15 The offered IAMS system shall be suitable for running / loading advance diagnostic software of following makes of SMART Positioner : Metso, Fisher, Dresser.

4.2.2.1.14.16 The plug–in advance diagnostic / valve signatures software of Smart positioner, shall loaded on the IAMS station. However proper loading, integration and compatibility checking with the DCS vendor’s IAMS system shall be the complete responsibility of Contractor. Any other specific software other than plug-in software, if required by for implementing advanced diagnostics features in IAMS shall be supplied by Contractor / DCS vendor.

4.2.2.1.14.17 ---.

4.2.2.1.14.18 The large screen shall be integrated with the PLANT CCTV system. It shall be contractors responsibility to integrate the same and supply all necessary hardware, software including cable between CCTV system and large screen.

4.2.2.1.14.19 The time synchronization with external clock i.e. GPS shall be provided by DCS vendor as per clause 5.8.3 of Part-I of Job standard specification for DISTRIBUTED DIGITAL CONTROL AND MANAGEMENT INFORMATION SYSTEM (DCS) for DCS, PLC, IAMS, OPC, BMS PLC and other third party devices like VMS etc.
4.2.2.14.20 For Analog output of DCS, the barriers shall be provided with line fault detector.

4.2.2.14.21 All proximity probe input to PLC / DCS shall be provided with IS barrier cum pre-amplifier.

4.2.2.14.22 Fan failure alarm shall be provided in DCS individually for all cabinets.

4.2.2.14.23 For all split range applications the controller shall provide two independent output signals one for each control valve.

4.2.2.14.24 Separate cabinet shall be provided for analog, Digital signals separately for DCS and PLC as applicable. Similarly separate cabinet with interposing relays shall be provided for MCC inputs and output.

4.2.2.14.25 Type of report generation shall be finalised during detail engineering by operation/process department of client.

4.2.2.14.26 Screw less terminals shall be considered by contractor for all terminations. All terminal shall be sourced from reputed make like WAGO.

4.2.2.14.27 Fabrication / installation of Channel base frame and modification of finished floor in Control Room shall be under Contractors scope.

4.2.2.14.28 Civil work related to provision of cable entry in wall of Control room is also be in Contractor scope.

4.2.2.14.29 -

4.2.2.14.30 Repeat indication in field shall be in series with transmitter for open loops whereas for closed loops it shall be from control room using Dual output barrier. For close loops contractor shall also provide separate IS output barrier for signal transmission to IS local indicator in addition to dual output barrier.

4.2.2.14.31 For control systems where the architecture necessitates that the transmitter power supply be segregated from controller power supply and the input/output power supply, the system shall be designed with capability to discriminate between transmitter failure and zero signal value. The detection of the transmitter failure shall be alarmed and shall cause the controller output to be held at the prior valid signal output value until the operator takes action by transferring the control to manual.

4.2.2.14.32 Expandability Philosophy
All the spares shall be calculated based on various requirements specified in the PR, including I/O summary, power supply etc.

4.2.2.14.33 Communication Sub-system

The communication subsystem cable shall be secured in G.I. conduit pipe inside the control room. The communication subsystem, in each case must perform to the offered specifications for error rate, signal attenuation, noise immunity, etc. No other cable (signal, alarm,power) should be kept in GI conduit.

All communication cables, data highway cable routed in the field shall be via dual redundant fibre optical type. The optical fibre cables shall be with two layers of steel tape armouring. Contractor shall provide specific converters wherever necessary for the same. All fibre optical cables shall be routed through hard HDPE conduits and shall be totally enclosed within using HDPE matching fittings. The HDPE conduits shall be as per IS-4984 or equivalent IEC standard. The outer colour of the conduit shall be orange with black fittings throughout the run. Use separate conduits for laying redundant fibre optical cables. Wherever fibre optical cable is to be routed underground, this shall only run in tray provided in concrete trenches with
HDPE conduits provided as above. For redundant system / fibre optic / serial link, the two cables shall be laid apart as far as possible in same cable tray.

Contractor may use common fibre optical cables to carry more than one data signals. In such cases, separate fibres shall be used for each of the signals. For all such multi fibre cables, provide minimum four fibres for future use. Individual fibre optical cable if used shall have minimum one pair of spare fibre. All fibre optical cables shall be rodent resistant and armoured type only.

4.2.2.1.14.34 Connectivity with Central Control Room and Advanced process control (APC) server

4.2.2.1.14.35 The control system for new PLANT shall be connected to client’s Central control network by using the OPC Servers in DCS system. Contractor scope and responsibility shall include establish connectivity between OPC server and PLANTDCS System.

4.2.2.1.14.36 Contractor shall provide the web based server with firewall for remote log in. Web Based server shall be a UHN and shall meet the specifications for UHN.

NOTES:-

*** For these systems Remote I/O panels with push buttons, indication lamps and annunciation shall be provided for subsystems where manned local operation is required.

1. For soft-link communication between PLC and DCS, PLC Vendor shall supply PLC end Modem/Converter and DCS Vendor shall supply the DCS end Modem/Converter. Communication armored cable between PLC to DCS shall be in PLC Vendor’s scope. Communication protocol between the Modems shall be RS485/Modbus and the maximum communication time for receipt of signal at DCS end should not exceed 2 seconds. **There shall be only one soft link between Station C&I DCS and each PLC.**

2. PLC Vendor will provide necessary industrial grade redundant UPS power supply with 60 minutes battery backup for PLC Control Panels, Operating station & printer etc. In case MCC are in the package vendor’s scope, then package vendor shall arrange feeders for power supply with all hardware and cables. Provision should be made in DCS & PLC for redundant communication (Modbus TCP/IP, Cu) with Electrical LMS for communication of Electrical HT & MCC Data.

3. Whenever control system is PLC based, annunciation system shall be driven by PLC. For other control systems, solid-state annunciation system shall be provided.

4. Deleted.

5. PLC system without OEWS (Operating & Engineering Work Station) shall have panel mounted push buttons, lamps, H.W. annunciation and MIMIC etc for operation & control purpose.

6. All the PLC control system shall be of one make and shall be supplied directly from manufacturer/vendors. PLC system supplied/engineered by system houses shall not be acceptable.

7. All remote I/O cards if any shall be with IP-65 protection class and should withstand up to 70 deg.C temperature.
8. All cables terminated in the terminal block (Phoenix/ Wago / Weidmuller or very standard make push in type terminal block to be used.), power distribution scheme instruments shall be ferruled. Ferruling shall be double cross ferruling (i.e.) source and destination addresses shall be marked on both sides of the tube ferruling.

4.2.2.14.41. Foreign Device Interface Sub-system

PLC, vibration & temperature monitoring system, Machine monitoring System, BMS, anti surge controller, Analysers and Chromatographs, etc. shall be interfaced with DCS. The interface shall be dual redundant with auto time synchronization and with interface diagnostic available at both central level and at local level. The interface shall be of serial type.

The following shall be noted:

- The serial interface shall be through controller & data acquisition subsystem / processor subsystem and the no. of serial links per serial interface module shall be restricted to 4 subject to meeting loading criteria.
- Total no. of redundant gateways / serial interface modules shall be calculated and provided accordingly by contractor for each network meeting the other requirements of specification.

It is Contractor responsibility to co-ordinate with the supplier of foreign devices identified in design basis and establish communication for transfer of data with them. Unless the above communication is established, the Control System shall not be considered commissioned. It is the responsibility of the contractor to make final documentation for interfacing details.

Contractor to ensure that there should not be any operational disturbance in case of failure of serial link communication. Necessary hardwired instrumentation as required for this purpose of smooth interfacing with foreign devices to be selected by contractor as part of detail engineering. The link shall allow bi-directional signal transfer from foreign device system to DCS.

4.2.2.14.42 Hardwired Console Layout

The detailed layout for Hardwired console shall be worked out during detailed engineering by contractor. The layout for all hardwired consoles shall be reviewed by the PMC / Owner.

Hardwired console shall match with the operator consoles including the dimensions. The No. of Hardwired console shall be decided based on functional requirement.

Hardwired console shall be of mosaic finish design for ease of adding/ deleting any hardware on the console. It shall be possible to add or remove any item from console front by removing or adding mosaic tiles.

When selector switches are specified and current signals must be used, dummy load resistors shall be provided to maintain circuit continuity in all switch positions.

The HWC shall be installed along with operator interface subsystem as man-machine interface, which shall be equipped with indicating lamps, pushbuttons, Selector switches etc.
For preparing HWC drawing Contractor shall note that all push buttons / selector switches as indicated / required (manual reset of trip, manual activation of trip, control room reset for solenoid valves etc.), auto start / stop logic for pumps, compressors and other packages shall be indicated on HWC layout drawing with appropriate tag no. and legends.

All HW items like PBS, lamps etc. shall be of miniature type IDEC IZUMI, EAO or equivalent. Back-lighted push-buttons / switches for status indication on HWC shall be considered.

Provision shall also be kept for keeping Plant communication console / Handsets also on hardwired console.

Alarm annunciator shall be hung from the ceiling for which necessary mounting accessories, mounting rod, cable support shall be supplied by contractor. Necessary steel insert plates and supports for mounting ceiling hung type Alarm Annunciator shall be provided by contractor.

4.2.2.14.43.1 For laying of cables outside buildings, contractor shall lay cables in cable trenches / trays / trays.

4.2.2.14.43.2 All system cabinets (DCS, PLC) shall be provided with toughened glass door at front side; all other specifications of cabinet shall be as per datasheet and Job standard specification for DCS.

4.2.2.14.43.3 EARTHING REQUIREMENT:

Dedicated redundant earth pits shall be provided for both signal (IS), Non IS, Panel and chassis (system) grounding for DCS/PLC Earthing system at Control Room. Preparation of earth pits outside Control Room shall be under Contractor scope. Supply of earth electrodes, grounding cables (separate for signal grounding and instrument grounding) and other related accessories required for barrier earth, system earth and installation shall also be in the scope of work Contractor. Copper conductor shall be of 1Cx10 Sqmmas minimum. For surge protection devices separate earthing shall be used.

Grounding requirement for other system to be taken care by Contractor

Earthing of all new equipments / instruments located at control room for New PLANT of new earth pit at control room, if the existing earthing pit is not suitable the necessary new earthing pit with all cables, electrode, pit shall be provided by contractor.

4.2.2.14.43.4 All items shall be supplied from PMC / Owner approved contractor list. For any items not listed in approved contractor list, contractor shall obtain prior approval from PMC / Owner before ordering.

4.2.2.14.43.5 All Panels, cabinets shall be of RITTAL or Equivalent. Entry to Cables in the cabinets of DCS / ESD shall be through SS single compression weatherproof IP55 cable glands or MCT IP55 blocks. Load bearing capacity of panel shall be 1400kg and shall follow IEC 62208 multifolded profile panel. Against external mechanical stresses as per EN50102 / IEC62262 complete paint process including solvent will be RoHS compliance and automated.

4.2.2.14.43.6 Panels / Cabinet wiring / termination

a) Contractor to use OMRON make or equivalent relays wherever required. All DCS hardware including engineering console / operator console shall be proprietary equipment and shall be supplied through original manufacturer of the system. Other reputed make with requisite PTR shall be accepted only for SIL 3 relays subject to PLC contractor.
certify the same for its compatibility with their system and review/approval by PMC/Purchaser during detail engineering. Minimum no. of contacts for all relays shall be 2.

b) The ferruling philosophy/type shall be decided during detail engineering based on overall philosophy for the fertilizer complex. Unless otherwise specified, cross-direct ferruling concept shall be used.

c) Cabinet lighting shall be 230 V AC non-UPS only and the lamps shall be white threaded type. One no. additional socket for 230 V AC shall be provided in each cabinet for use of other testing devices.

d) In all analog marshalling cabinets provision shall be kept for mounting hand held configurator for smart transmitter.

e) All field cables shall be first terminated in separate TB (marshalling terminals) and further the same shall be connected to the barriers / relays.

4.2.2.14.43.7 The system and documentation and instruction manual CD/DVD shall be submitted with proper labelling and CD storage / carry case and not loosely.

4.2.2.14.43.8 Refer to the Job standard specification for DISTRIBUTED DIGITAL CONTROL AND MANAGEMENT INFORMATION SYSTEM (DCS) clause 2.2.2.7 of Part-II, all I/O's (100%) shall be simulated in controller and data acquisition sub system to verify proper system response for both analog and discrete signal.

4.2.2.14.43.9 Contractor shall carry out tuning of controller, complex control scheme simulation, interlock simulation at site during field testing.

4.2.2.14.43.10 System installation audit shall be carried out by system expert technical audit team of the contractor for the entire DCS / PLC system including all subsystem to ensure compliance to the contractor's quality installation procedure. Such audit shall be carried out during system internal loop checking & field loop checking for all I/Os, interlock simulation, taking all the controls including complex controls in auto mode, tuning of controllers, proving of all subsystems. OEM's technical audit team shall carry out following minimum checks at site before power on and detailed report shall be furnished.

1) Earthing checks.
2) PDB checks.
3) System bus cable laying as per recommendation.
4) Individual cabinets wiring checks.
5) Hardwired console / HAAS checks.
6) Third party system checks, etc.

4.2.2.14.43.11 Site acceptance test for all the subsystem /packages to be considered i.e AIMS, IAMS etc.

4.2.2.14.43.12 Procurement and Engineering done by contractor on third party procurement if any shall be certified by original equipment manufacturer.

4.2.2.14.43.13 Contractor to provide / select the best possible accessories / peripherals of PC during detail engineering for PLC and DCS system.

4.2.2.14.43.14 Graphic, control Groups, Trends, logs and reports shall be approved by purchaser prior to start of engineering/ implementation, however plant graphics colour shall be as per existing plant operating philosophy.
4.2.2.14.43.15 Wiring for Inputs and outputs to the PLC system shall be as per the OEM recommended philosophy that is with use of recommended FTA boards (with fuse blown indication), TB’s, barriers etc. Recommended philosophy must have requisite PTR.

4.2.2.14.43.16 Rodent control after start of cabling to Site acceptance test shall be done by contractor in the control Room.

4.2.2.14.43.17 For anti-surge controllers, field cables to/ from transmitters/ anti-surge control valve to be directly wired to anti-surge controllers console and outputs also to field directly, not via marshalling panel.

4.2.2.14.43.18 Static transfer time will be verified during SAT or before SAT by online changing over the UPS, by pass UPS, UPS on battery bank etc. The functionality of DCS, PLC should not be affected. Contractor to demonstrate at site after the Power on of the system.

4.2.2.14.43.19 Emergency shutdown switches (push buttons) shall be red in colour and Push type with lamp and cover protection.

4.2.2.14.43.20 Cable entry into the Control Room shall be through Multi Cable Transit (MCT) blocks and is in contractor scope of supply. The MCT frames shall be of standard RGB type of M/s Brattberg or G type of Roxtec or equivalent and of stainless steel or galvanized steel construction including frames, stay plates, wedges bolts etc. The MCT block shall be provided with centre core with adjustable OD with peeling off arrangement. Contractor shall provide 20% spare usable insert blocks in each cable size/O.D. as loose supply.

4.2.2.14.43.21 The power cables for instruments shall be suitably separated from the other cables and shall be routed through separate MCT blocks. In general, the MCT frame considered for instrument shall not be used for electrical cables.

4.2.2.14.43.22 The MCT shall be installation as per the recommended practice of supplier. No spare space shall be left uncovered in the frame. The same shall be provided with MCT block with secured centre core. The size of quantity installed spare block on MCT shall be proportional to the blocks used for cables.

4.2.2.14.43.23 Contractor shall provide necessary cable tray inside the rack/ of Control Room and Cable tray/ tray as required in Control Room/rack /console/ engineering/ training room in Control room for laying of cables below the finished flooring i.e. in cable at control room. The trayshall be properly supported by contractor from the bottom of the cellar roof and trayshall be covered from all the sides. The traywidth shall be 600 mm in general and it shall cover the cutout portion of the floor. The traymaterial shall be of perforated aluminium material.

4.2.2.14.43.24 For Operator console & SOE PC, engineering console, AIMS and IAMS PC shall be minimum sever grade with dual hot swappable power supply and RAID configuration, The detailed requirements are specified in Attachment Specification of Server grade.

4.2.2.14.43.25 Site Acceptance shall be carried out as per clause 5.0 of Part-II of Job standard specification for Distributed control system.

4.2.2.14.43.26 The Owner / PMC / Licensor shall participate in the following areas of system engineering:
Kick off Meeting, System definition Meeting, Software Definition Meeting & other Engineering review meeting.
Review of system sub contractor drawings / documents.
Factory acceptance test at sub contractor works for bought out items & FAT
For DCS/PLC.
Loop Checking / testing & commissioning.

4.2.2.14.43.27 The Project schedule shall be made during KOM for achieving the various milestones.

4.2.2.14.43.28 Any meetings considered necessary by PMC / Owner in order to achieve the Project schedule with DCS contractor, the contractor & DCS contractor shall consider the same at discretion of Owner / PMC.

4.2.2.14.43.29 AIMS shall be from IMAC or X-Force (M / s SSM Infotech) or equivalent reputed make meeting the specification and PTR requirement.

AIMS shall be a fully configurable system capable of processing all alarms in an appropriate manner to maximize the information provided, but to minimize the number of alarms displayed with suppression and / or filtering techniques. AIMS shall have capability to analyze various alarms / data and inform plant operator the probable reason, make recommendations as the action to be taken and provide operational alternatives in case of unit start up and upset condition. AIMS shall have capability to generate / compute alarms based on a logical combination of states, conditions and events. The purpose of Alarm Information Management System (AIMS) is to provide a centralized Alarm information which shall be used for acquiring, sorting, adding value and provide redistribution

4.2.2.14.43.30 DCS I/Os for all closed loops shall be redundant.

4.2.2.14.43.31 No Remote I/O shall be used for this project.

4.2.2.14.43.32 Separate rack shall be considered for Gas Detectors. PLC rack allocation shall be from any one of the PLC. Also rack shall have DO cards for generating Hooters / Beacons.

4.2.2.14.43.33 Process Licensor / Package Contractor shall witness the FAT at DCS system contractor’s works.

4.2.2.14.43.34 All the serial interface points coming from each foreign device shall be interfaced and annunciated in DCS.

4.2.2.14.43.35 Smart Positioners are considered by purchaser for Partial Stroke Testing on ON-OFF Valves and these positioners shall be connected to AO cards of DCS (open loops). Contractor shall demonstrate the partial stroke testing during DCS system FAT.

4.2.2.14.43.36 Wherever Fault Tolerant Ethernet Switch is considered for connection of fibre optic cables, the make shall be preferably from CISCO. Separate Ethernet switch shall be considered for each bus cable. No. of ports (IN & OUT) shall be indicated for switch. Ethernet switch shall be mounted in a separate cabinet at both locations.

4.2.2.14.43.37 Contractor in addition shall supply the following

- Four no. of LED / LCD clock with GPS connectivity
- Six numbers of panel mounted phones for operator console and four numbers of cordless phones for Operator chairs for all DCS and PLC operator / engineering consoles and workstation. Quantity shall be estimated based during detailed engineering.
- Necessary furniture for housing documentation and spares
- CD storage case for system and documentation and instruction manual CD/DVD with proper labelling
- Contractor shall provide two numbers of Cu (Cooper) and Au (Silver) corrosion transmitter (4-20 mA and RS3485 interface to DCS) in the control room of Purafil or Circulaire make.

### 4.2.2.2 HART MAINTENANCE SYSTEM

In order to aid maintenance of Field transmitters, a common “Hart maintenance system” has been envisaged for all the units. This system shall interact with all Smart Transmitters to provide:

a) Monitoring of device (Smart Transmitters) status on-line.
b) All maintenance related data like diagnostics alarms, transmitter range, settings etc.
c) Trend Data for all devices.
c) Facility to re-range, configure and calibrate field transmitters.
e) An audit trail for a complete historical record of all configuration, calibration and device alerts.
f) Data on predictive maintenance such as list of transmitters experiencing drift.
g) Advanced diagnostic features like device step response, device signature, dynamic error band etc.
h) Documentation like various trend reports, Diagnostic reports, and predictive maintenance reports, audit reports, historical data and device specification sheets in addition to those available with selected software as stand-alone.

Definition, engineering, configuration, loading and compilation of all reports whether specifically indicated in this specification or available as standard with the selected software shall be in the scope of contractor.

The systems shall be supplied fully engineered with all the tag nos. for the smart transmitters configured.

### 4.2.2.3 ANALYZER SYSTEM

#### 4.2.2.3.1 Contractor shall be responsible to supply complete analyser systems for PLANT.

a) Contractor scope shall include supply of all stack analyzers indicated in the P&ID’s duly installed in analyzer shelters complete with sample system designed for the specific purpose.

b) The analysers shall be supplied as per licenser’s specifications. The following shall be considered by contractor;

i) The sample handling system design for each Analyzer shall be carried out by analyser manufacturers and submitted for Owner's / PMC’s review.

ii) Traced sample lines wherever required shall be traced pre-fabricated insulated tubes of DEKRON or eqv.

iii) For stack analysers, contractor shall provide reports as per ODISHA pollution control board requirements.
iii) Scope of supply shall include carrier gas, calibration sample cylinders for zero as well as span calibration of each analyzer for a period of one year after the system acceptance. The calibration sample requirement shall be calculated based on once a day calibration. For sample blends which deteriorate with time, contractor shall consider the deferred delivery of the cylinders. The cylinder material of construction and rating must be certified. The calibration sample concentration must be certified for their guaranteed accuracy over a period of one year.

iv) Contractor shall be fully responsible for satisfactory performance of all the analyzers. Contractor shall also arrange analyzer vendor's assistance during site testing, calibration, commissioning and site acceptance of analyzer system. All other activities are expected to be carried out at manufacturers' works.

HVAC system shall be dual without any shared components. One shall be working and other standby.

All Online Analyser shall be considered as per the process licensor requirement and P&ID. Only Ex-proof analyzers are required. Only certified Ex ip analyzer shall be provided if no ex-proof version is available.

Analyzer shall be located to keep the sample tubing run as short as possible to minimize transport time delay.

- Sample handling components that require periodically maintenance / replacements like sample pumps, filters, etc shall be dual; one working and other standby.
- Flow indicators, Pressure gauges and temperature gauges shall be provided as required to properly maintain sample, sample by-pass, sample vent and utility flow rates and other parameters. Also they shall be permanently tagged to show the required values.
- All SHS shall have provision for lab sample grab.

Critical analyzer sample and utility parameter indication shall be provided in DCS.

a) Process analyzers shall be supplied as specified in the P&IDs enclosed with the Process package and as per licensor's specification. Where no specifications are available in the Process packages, contractor shall detail out the same in line with international codes and practices, process data and process package specifications provided with this document and last but not the least as per good engineering practices followed by analyzer industry.

In all such cases, contractor in their own interest must get performance specification reviewed by Owner / PMC before proceeding with further engineering & procurement.

b) All the analyzers shall be installed in prefabricated analyzer shelters unless indicated specifically otherwise in the process package/P&IDs.

c) Number of analyzer shelter, location of analyzer shelters and number of analyzers installed in each of these shelters shall be decided based upon:

i) Allowable transportation time for each sample.
ii) Available space requirement for analyzer shelter room.
iii) Accessibility with respect to approaches & obstructions.
iv) Space required for equipment maintenance and calibration.
v) Proving the analyzers as per process requirements specified by process licensor.
In no case, the transportation time should exceed the recommended figures indicated by licensor in the Process package. Incase no value is indicated the transportation time should be considered less than one minute.

In case more no of shelters are required, the same shall be considered by contractor For the purpose of analyser shelter sizing contractor shall consider the minimum width of 3000 mm and height of 2500 mm. The length should be decided based on factors indicated above.

d) Contractor shall consider provision of fast loops and sample return to process based on process package, process requirements, fluid handled, sample disposals and manufacturer’s recommendations as necessary to meet performance requirements. Where sample has not shown connected back to process in the P&ID, contractor shall provide a suitable sample return location and shall consider this as a part of residual engineering.

e) The design of sample handling system shall ensure a clean representative and measurable sample for the selected analyzers. System shall include sample probe, pressure reducing station, heat tracing, filters, coalaseer, regulators, safety valves, sample valves, sample pumps, sample cooler etc. However minimum requirements as specified in ‘Requirements for Analyser Systems’ attached as annexure-VI must be adhered to. The design must include a sample flow switch which will provide alarm and inhibit analysis whenever a low flow is sensed. Alarm for low flow and faulty analysers shall be provided at local as well as in control room.

f) Sample return to process shall be designed considering sample condition and return header process data. Where sample returns can’t be sent back to process because of degradation of sample (rendering it unsuitable for mixing with process stream), contractor shall develop a suitable disposal scheme. All such liquid hydrocarbon streams shall be disposed to close blow down header/system and gas samples to be connected to flare.

g) Analyser shelter shall be fully ventilated, pressurized and air conditioned and shall meet all the requirements specified in shelter specification (Refer Clause No. 4.6 of this document) and specification for HVAC system attached elsewhere in this document.

In case where any single process analyser can’t be located in shelter considering factors like transportation time with respect to vicinity with the analyser shelter; the analyser can be located in a suitable analyser cabinet provided with the cabinet mounted air conditioner suitable for the area classification. A suitable protection against dust, sunlight and rain shall also be provided. Cabinet shall be weatherproof as minimum.

h) The design must ensure the adequate number of air changes to render analyser shelter/room safe under normal conditions. However design should not consider recirculation of air for HVAC design.

i) All the analysers located in analyser shelter shall be suitable for area classification under ventilation failure condition. However an item which does not meet area classification shall be switched off whenever there is ventilation failure.

j) The material of construction selected by contractor must be suitable for process fluid being handled. Contractor must select SS316 as a minimum.

k) All analyzers shall be microprocessor based in general and shall be capable of providing detail diagnostic alarms, messages to help maintenance personnel.
I) Sample handling system shall incorporate auto calibration system to suit similar facilities available with the analysers. Wherever analysers auto calibration facilities are not available, calibration sample injection shall be done automatically using manual command. Contractor scope shall include provision of all hardware and software necessary to meet this requirement.

m) The process analyzer shall be connected to the DCS, which shall include the following:

   i) Each shelter shall be provided with facility for either hooking up a portable PC with each analyser or a fixed PC with a printer in each shelter for fault analysis, calibration or as a maintenance & monitoring tool.

   ii) All Process analyzer shelters and all analyzers shall provide 4 — 20 mA isolated output for remote indication on the Central DCS. Contractor may use serial output from analyser wherever available.

4.2.2.3.3 Stack Gas Analysers

a) Each stack shall be provided with flue gas monitoring analysers namely Sox, Nox, O2 or any other stack gas analyser specified in the process package. Number and type of analyser shall in general be as per details provided in process package or specified elsewhere in this package.

b) The stack analysers shall be housed in analyser shelter only. Location of these analyser shelters shall be decided by the contractor considering vicinity to the stacks and maximum allowable transportation time allowed by EPA / TUV. Typically transportation time of one minute may be selected in the absence of any guideline.

c) Stack gas analysers shall adopt dilution/hot extraction technique for drawing the sample from the stack. Contractor must design the sampling system meeting requirements of effective analysis and requirements of selected analysers.

d) All analysers as selected must bear the approval of international pollution board authorities like EPA, TUV etc. Analysers not meeting these certifications shall not be supplied. In addition to above contractor shall also be responsible for meeting local pollution control requirements set forth by state pollution control board.

e) Analser shelter if located in hazardous area shall be ventilated, pressurized and air conditioned and shall meet all the requirements as per clause 4.6 of this specification. Air to be sucked from the top safe location. The number of air changes shall be selected by contractor to render shelter/room safe during normal working conditions. In case of failure of ventilation, power supply to all these analysers shall be cut-off. In case analyser shelter/ house is located in safe area, the requirement of ventilation shall be evaluated by contractor. In any case, the analyser shelter/ room must be air conditioned in line with requirements and specifications specified elsewhere in this package.

f) The design of sample system shall ensure a clean representative and measurable sample for the selected analysers. System shall include sample probe, filters, regulators, sample cooler, etc. However minimum requirements as specified in ‘Requirements for Analyser Systems’ attached elsewhere must be adhered to. The design must include a sample flow switch, which will provide alarm and inhibit analysis whenever a low flow is sensed.

g) All stack analysers shall be microprocessor based and shall be capable of providing detailed diagnostic alarm, which shall provide helpful message to help maintenance personnel.
h) Analyser and sampling system shall incorporate auto-calibration facilities. All accessories to meet auto calibration facility like solenoid valve, timer etc. shall be supplied by contractor.

i) Analyser shall be capable of providing 4-20mA (isolated) output as well as serial (RS485/232) output to DCS. Analysers shall also have diagnostic/fault alarm outputs to DCS.

j) Analysers shall be selected by contractor to meet the ranges in the process data sheets or as specified by the heater vendor during detailed engineering. Requirements of State Pollution board shall be kept in mind while deciding on analyser ranges. Each component of interest / component as specified in the process package shall utilise a dedicated analyser. No two components shall share the same analyser or any component of analyser. However they may share the same sample lines provided these analysers share the common sample take off point. Stack mounted analysers and field mounted analyzers (except for Zirconia probe) shall not be acceptable. Various stack analysers shall meet the following performance specifications as minimum:

i) NOx Analyser- type- Online chemi-illuminance type
Repeatability- ±0.5% of full scale or better.
Linearity- ±1.0% of full scale or better.
Least detectable limit- ±0.5% of full scale or better.
Response time- <40 sec or better.

ii) SOx Analyser- type- Online UV absorbance.
Repeatability- ±0.5% of full scale or better.
Linearity- ±1.0% of full scale or better.
Least detectable range- ±0.5% of full scale or better.
Response time- <15 sec or better.

iii) O2 Analyser- type Zirconium oxide with remote mounted controller
Accuracy- ±2.0% of full scale or better.
Repeatability- ±0.2% of full scale or better.
Response time- <60 seconds or better.
Electronics in field shall be certified by for use in hazardous area.

iv) Other analysers such as
   a) Silica analyzer
   b) Sodium analyzer
   c) Hydrazine analyzer
e) TOC (Total Organic Carbone) analyzer
f) ORP (Oxidation Reduction Potential) Analyzer
g) DO (Dissolved O2) Analyzer
h) Chloride Analyzer Etc
i) SPM Analyzers
Can be added according to process condition.

4.2.2.4 CCTV MONITORING

The CCTV system shall be IP based.

4.2.2.4.1 Closed Circuit Television system for the PLANT units shall consist of the following elements:

a) High resolution charge coupled device (CCD) day & night, tamperproof color camera

b) Auto iris zoom lens, pan and tilt, near & far focus, screen wiper, ON/OFF control equipment, color monitor and video recorder system

c) Automatic computer based switching device including Quad splitter.

d) Ceiling hung CCTV monitors such that these can be suitably matched with control room aesthetics by dimensions appearance etc.

e) Coaxial cables, control cables, optical cables, connector etc. of required type & size.

f) Video recorder located in Control Room.

4.2.2.4.2 The complete hardware and software for PLANT shall be procured by Contractor.

Contractor scope shall include:

a) Identification of suitable location for mounting cameras in the field. Contractor shall coordinate the locations, with PMC/owner.

b) Installation of cameras and their associated accessories in the field (equipment free issued to contractor). This shall include any structure, support or stanchion required for installation and their accessories.

c) Cabling (cable shall be free issued to contractor) from respective camera to main control room and termination of cables in the field, as per recommendations by CCTV manufacturer. This shall include any additional support or tray/trayspace provision by contractor.

d) Coordinate with CCTV manufacturer/supplier during testing, pre-commissioning and commissioning of complete system.

e) Bidder to provide facility to connect FO cable from central control room CCTV network to steam generation plant network. Supply and laying of these FO cables will be in others scope.

4.2.2.4.3 The tentative number of CCTV camera shall be as follows:

PER PLANT nos.

i) In ash handling Area for each boiler one camera
ii) At the burner area total 5 no of cameras

iii) At burner feeding conveyors 2 no’s

iv) Deleted

v) There shall be provision to connect 4 more camera , bidder to provide sufficient space and power supply for the same for future.

4.2.2.5 TELEPHONE EXCHANGE AND ASSOCIATED ACCESSORIES.

BASIS OF DESIGN

The system and all the equipment shall conform with all relevant and the latest edition of Indian, International, OISD and CCITT/ITU standards using field proven microprocessor based design techniques for all processing and control functions. The exchange shall be based on a robust, reliable, virus protected, IP based platform for connecting IP phones, Digital phones as well as Analog extensions. As a minimum, the following standards shall apply.

a. IS: 2148 Flameproof enclosures for electrical apparatus.

b. IS:13346 General requirements for electrical apparatus for explosive gas atmospheres.

c. IS:5572 Classification of hazardous areas (other than mines) for electrical installation areas having flammable gases & vapours.

d. IEC:79(Applicable parts) Electrical apparatus for explosive gas atmosphere.

e. IS: 13408 Code of practice for the selection, installation & maintenance of electrical apparatus for use in potentially explosive atmospheres.


g. IS: 5571 Selection of equipment for Hazardous areas.

The offered exchange should be capable and equipped with requisite software / hardware for networking with different EPABX Systems of other makes for feature transparency.

The VOIP Box shall comply with the ITU-T, IEC Standards with latest amendments (if any). The system shall support fax messages via IP trunking

The telephony system shall be interconnected with the PA/GA systems such that communications can be automatically established by authorized subscribers of any of the systems without operator intervention.
The telephony system shall also be connected to the Public Switched Telephone Network (PSTN) through the PABX, and shall comply with all the telecommunication carrier’s requirements; technical compatibility between the public and private networks shall be ensured.

SERVICE CONDITIONS

All the equipment shall be suitable for the site conditions as specified in design basis. Indoor equipment shall be installed in a HVAC controlled environment.

AREA CLASSIFICATION

All the outdoor equipments shall be suitable for installation in hazardous area and shall be Flameproof to Ex-d IIC/T6 and weatherproof to IP67 as per IEC529, irrespective of plant’s hazardous area classification.

All the outdoor equipments shall have certification for use in Zone-1, Gas group IIC/T6, irrespective of plant’s hazardous area classifications and by the recognized testing and certification authorities such as ‘CMRI’ Dhanbad, BASEEFA (UK), UL (USA) etc., or the relevant authorities of the country of origin.

Indigenous equipment for hazardous areas shall be approved by CCEO and all flameproof equipment shall be under a valid BIS license.

The exchange shall be fit operate on the following power supply.

a) UPS Supply voltage 115 A.C. ±10%

b) Supply frequency 50 Hz ±3%

DESIGN SPECIFICATIONS:

The system shall comprise of fully microprocessor based digital central exchange(s) consisting of system control hardware, which shall be located at central control room. It should be an expandable system. The system shall have capacity of 50 extensions. The systems exchange shall be extending up to 100 telephone lines. It should support IP / Digital / Analogue phones. A redundant interface for connecting any other Telephone Exchange.

An Internet Protocol (IP) based telephony system shall be provided. The Exchange shall have facility of connection to the LAN system with POE switches.

The Telephone Exchange shall be interfaced with FGS system via 2 wire, RS-485 serial interface over MODBUS. The Telephone Exchange system shall provide general failure alarm signals for presentation on the DCS system in the Control Room (CR).

The telephony system shall be interconnected with the PA/GA systems such that communications can be automatically established by authorized subscribers of any of the systems without operator intervention.

The EPABX and a Main Distribution Frame (MDF) shall be located at control room. CPU and power supply shall be provided with 100% redundancy. Each office (or equivalent) telephone
set shall dispose of two connection possibility points as a minimum. The additional connection points could be used either to change location inside the room or to add further telephone subscribers.

The cable supply and installation rules shall follow the same rules than the instrumentation cables. The telephone JB supply and installation rules shall follow the same rules than the instrumentation items. The system shall have automatic broad casting of alarm when a fire or gas alarm signal is initiated from the fire and gas system. Bidder has to provide complete layout of the Telephone network in its scope of the building. Complete supply, erection of the exchange system shall be in bidder scope. Bidder has to provide complete system in fully working condition.

The IP EPABX system must support IP TRUNK (SIP (mandatory) and should permit management of communications between SIP terminals and the traditional telephony devices (IP, analog, private or public lines). Central exchange and switches shall be provided with Redundant FO port. FO cable laying and supply will be in scope of others.

The offered exchange should be capable and equipped with requisite software / hardware for networking with different EPABX Systems of other makes via QSIG protocol (QSIG-SIP, QSIG-PRI, QSIG-Analog etc.) for feature transparency as per ECMA Standards (QSIG over ISDN & IP trunks).

The EPABX shall be suitable for up to minimum 5 digit extension numbering scheme. This numbering scheme should be flexible. System shall also allow mixed numbering scheme (open & closed numbering).

EXCHANGE

The central exchanges shall be fully digital, microprocessor based freely programmable exchanges, working independent of each other. Programming shall be by means of user friendly menu driven software via a dedicated lap top, which shall also be supplied by the system vendor. The specification of laptop shall be latest Intel hardware, Microsoft OS and MS Office software at the time of supply. It shall be possible to program / re-program the exchange through external laptop PC, using text/graphic editor, via USB/RS 232 or other suitable interface. This shall enable the user to carry out the following operations without any additional software. It shall be possible to interface the system with Fire Alarm system via RS485 serial interface over MODBUS protocol and with the central EPABX system via EPABX digital lines. The exchange shall have conference module. Complete hardware racks related to both these exchanges shall be accommodated inside control room at central cabinet room in a common panel/cabinet. The cabinet shall be fabricated out of minimum 16-gauge sheet steel, naturally ventilated, dust and vermin proof with IP-41 enclosure as a minimum. The panel shall be with swing out assembly of plug-in-card racks.. It shall be possible to locate faults by monitoring from the cabinet.

The central exchange shall have a processor module for the control of the central exchange. The exchange shall have a completely non-blocking type switching system and associated circuitry for call recognition and acknowledgement. The offered system shall be flexible and modular in construction with the possibility of expanding to a bigger system in the future. All hardware necessary for fault isolation and troubleshooting shall be supplied as a part of the cabinet along with each exchange.
The system shall have capacity of 50IP extensions. Bidder has to supply the following number of telephones as a minimum for all the plant area and closed buildings.

<table>
<thead>
<tr>
<th>Area</th>
<th>Required Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Generation Area</td>
<td>6 Nos (2 for each unit)</td>
</tr>
<tr>
<td>Analyser shelters</td>
<td>1 No for each</td>
</tr>
<tr>
<td>Control Room</td>
<td>20 Nos</td>
</tr>
<tr>
<td>MCC/Sub stations</td>
<td>2 No for each</td>
</tr>
<tr>
<td>Other facilities</td>
<td>4 Nos</td>
</tr>
</tbody>
</table>

4.2.2.6 LOCAL AREA NETWORK (LAN) FOR CR

The Bidder shall lay the LAN required for Main CR area.

BASIS OF DESIGN

The system shall have as a minimum the following for CR:

1. Manageable L2 switch with 1G/10G port, Jack panel and cable manager. 50% spare port shall be kept in L2 switch.
2. Switch shall have with 4 redundant Fibre optic port. One redundant Fibre Optic Port shall be used for connection to main Plant LAN switch/servers.
3. Cabling shall be CAT6A cabling. UTP CAT6A cabling shall be done with one spare cable.
4. 24 Nos 6 m/Cat6a patch cords for end user
5. Cable and passive components shall be from AMP. I/O

4.2.2.7 EXECUTION METHODOLOGY FOR SYSTEMS

Refer Job Standard Spec for DCS_PLC and section 3.3.3
4.2.2.6.1 DCS& PLC system envisaged for monitoring, control & Interlocks of PLANT shall be installed in CONTROL ROOM by Contractor.

4.2.2.6.2 The supply engineering, testing, installation, commissioning site acceptance etc., of the control system catering to above units is in the scope of the Contractor.

4.2.2.6.3 Contractor shall also be responsible for the system engineering, field-testing and site integration of control system with existing DCS/PLC system pertaining to New PLANT. The scope shall also include conducting the various meetings with DCS& PLC vendor for smooth execution of detailed engineering, generation of all DCS engineering documents, review of DCS/PLC vendor generated drawings and documents, co-ordination with DCS vendor, participation in factory acceptance tests at DCS/PLC vendors shop, participation in field testing and any other activity needed for successful commissioning of PLANT unit with field and control system fully integrated.

4.2.2.6.4 Drawings/documents which are required for the engineering of DCS/ PLC and other control systems pertaining to the PLANT shall be developed by the contractor. The engineering of control systems shall be carried out based on the general philosophy to be followed for all the units of the refinery and the philosophy shall be furnished to the contractor at the time of engineering. The completeness and correctness of the control system engineering documents for the PLANT shall be contractor's responsibility. These shall include, but not limited to the following:

a) Functional schematics and I/O count duly segregated based on the various type of field inputs like IS & NON IS signal, etc.,

b) Overview / group view assignment
c) Trending requirements and assignment
d) Dynamic graphic display
e) Logging and report requirements with formats and tag no.
f) Instrument details (Database) including those of package units.
g) Operator guide messages
h) Alarm management and page assignments
i) Control room engineering for Package units.
j) Logic diagram
k) PLC display requirements
l) Advance control requirements, if any
m) Serial interface details and tag assignment
n) Package unit interface details
o) Any other requirements! inputs as found necessary.

4.2.2.6.5 Contractor shall be responsible to ensure that the system is configured as per the requirements. Contractor shall involve their personnel in the various phases of project like.

a) System Design
b) System engineering including participation in kick-off, system definition, functional design and approval meetings, engineering review meetings etc.
c) System testing, integrated factory testing and acceptance
d) System vendor drawing review/approval
e) System testing at site including loop testing etc.
f) System commissioning and site acceptance testing.

4.2.2.6.6 Contractor shall provide all necessary inputs and protocol details to regarding various system oriented items like analysers, Steam Governor control system etc. for proper interface. It is the responsibility of contractor to coordinate with their system suppliers and provide all necessary details in specific formats/soft media etc. as required by the DCS vendor for interface. Contractor shall supply either the serial device or its simulator during integrated factory testing. Unless the interfacing is established, the contractors respective system shall not be considered commissioned.

4.2.2.6.7 Contractor shall review totality of sub-package vendor drawings including P&ID's, documents required for system engineering and ensure the same are in line with the process philosophy followed in process units.

4.2.2.6.8. -

4.2.2.6.9 The control room layout including console and racks. Factory Acceptance Test & Site Acceptance Test procedure are common documents for the plants referred. Contractor shall provide the inputs as required by system vendor for configuration. The inputs shall be provided separately for each unit.

4.2.2.6.10 The loop checking shall be carried out in coordination with DCS vendor as detailed elsewhere. It is essential that dedicated team of skilled personnel are positioned at site so that site execution activities like installation, loop checking, commissioning, SAT etc., are carried out independently and concurrently as necessary.

4.2.2.6.11 -

4.2.2.8 Monitoring and Protection of the Turbo/Compressor Train

For the purpose of monitoring the “health” of the machine and for automatic shut-down in case of emergency, a highly reliable continuous monitoring system shall be supplied. The monitoring system comprises machine mounted sensors and transducers and the monitoring instruments installed in the auxiliary panel the central
control room. The monitoring system shall have built in computer interface unit(s) for connection to an overall monitoring and diagnostic computer system.

4.2.2.8.1 Sensors

The complete system shall be from the same instrument manufacturer, Bentley Nevada 3500 series, in order to have single source system responsibility. Below is listed the minimum number of sensors required. The list is indicative and should not preclude the vendor from including other parameters which in his judgment are necessary for the safe and reliable operation of the train. Temperature sensors shall be mineral insulated duplex RTD elements. In all sliding surface babbitt bearings, the temperature sensor should normally be between 0.75 mm to 1.5 mm under the surface of the babbitt to ensure that the wall thickness is sufficient to prevent the oil pressure from penetrating the babbitt.

No common trip DO output of two different parameters from Machine protection system is acceptable (for e.g. Axial/Vibration trip clubbed into one DO is not allowed). Trip signal from MMS system to ESD system shall be on 2oo3 logic based, ie, three Dos from different cards shall be taken to ESD system as 3 different Di to different cards. Two sensors per radial bearing (one for redundancy) at the calculated maximum load deflecting bearing under abnormal conditions.

One sensor in each two shoes for thrust bearing on both the active and inactive side. Sensors on the machine case at various locations in accordance with the machine vendor’s recommendation.

Vibration and Thrust position sensors shall be Eddy current proximity sensors in accordance with API 670 latest edition. To allow adjustment and replacement during operation, external probes with no connectors or probe lead wires inside the machine is preferred. If internal probes are provided, they should be mounted on rigid brackets that will not vibrate and the armored lead wires shall be sufficiently long to terminate in weatherproof connectors outside the bearing housing. Necessary supports, strain anchors and suitable feed shall be used where required inside the machine.

Two sensors at or near radial bearing, 90 degrees apart and normally 45 degree from each side of the vertical centre. Installation at the nodal points shall be avoided under any circumstances. The X-Y probes shall be in the same radial plane throughout the machine train. It is desirable that one of the mid turbine probes is a dual probe consisting of a seismic velocity transducer and a proximity probe. The seismic transducer may be un-monitored and used for connection to diagnostic instruments.

Two axially oriented sensors at each thrust bearings with at least one of them observing a surface i.e., integral to the rotor. It is preferred that none of the probes are monitoring the thrust collar, as the thrust collar may get loose and the axial probe monitoring the thrust collar no longer measure true rotor movement. One key-phasor radian on the driver of the machine train with a corresponding one event per revolution marking groove under the probe. It must be ensured that thrust float and differential expansion do not move the mark out from under the key-phasor probe. Bentley probes material as ceramic capped for high temperature applications.
Key phasor measurement shall be provided for compressor LP/HP and turbine.

**4.2.2.8.2**

Monitors shall be of Bently Nevada make series 3500. The monitors for the machinery protection system shall be installed on the panel in the local compressor control room. Installation and area classification shall be in accordance with the plant requirement. All instruments shall be highly reliable and shall conform to API 670 latest edition. The machine supplier must ensure that the potential free contacts are available from the system for all alarm and trip signals. The monitoring system shall comprise of the following instruments:

- Power supply for provision of the DC voltage necessary for the system but with a separate power source for the key-phasor.
- Digital shaft speed indicator operated from the signal supplied by the key-phasor probe. The indicator shall have provision for repeating the speed signal to the central control room. The repeater signal shall be a pulse signal. Local indication of speed shall also be available near the machine.
- Dual voting thrust position monitor for each casing, designed to prevent false trips due to transducer or collar failure. The monitor shall have built in adjustable time delay of 0 - 3 secs.
- Sensor output panel for termination of unmonitored transducers used for periodic checks and diagnostics.
- Temperature indicators with high alarm relays form radial and thrust bearings.

All information from the backplane electronics of monitoring instruments in the local control room shall be available in the central control room. The transmission shall be through serial communication. However all vibration, axial displacement and speed signals are connected with DCS through 4-20 MA loop. All interfaces, bus cables and PC shall be supplied by the vendor. The computer for transient data management system shall be located in the central control room.

Two plane radial vibration monitors for each casing for continuous monitoring of the outputs of the two radial probes mounted 90 degrees apart at the same bearing. The installation shall be such that either of the transducer pairs from the same casing can be connected to the monitor. The monitor shall be designed to prevent false trips due to transducer failure and shall be provided with built in time delay.

Transient Data Manager of Bently Nevada/equiv make shall be provided for monitoring data from all compressors.

VMS/MMS I/O modules shall be within built Barriers. 4-20mA for DCS. MMS to be provided with System-1 monitor. Rule Packs also to be provided.

Interlock, shutdown and trip signal shall be hardwired to PLC (Contact signal from machine monitoring). All analog signal from VMS to DCS shall be hardwired. RS232C/485 Communication) shall be given as an additional provision. Also Ethernet port shall be provided for connecting the VMS to configuration & diagnostic station (PC based.)
4.2.2.8.3 Speed Control of Turbines (If, applicable)

All the over-speed trip and monitoring system shall be implemented in latest Woodward/Protech/Braun make systems. The speed control system shall be designed to provide maximum economy of operation and high reliability with a minimum of maintenance, and shall fulfill the requirements in API 512 standard.

Speed control and over-speed systems shall be independent. There shall be separate TMR over speed trip system for the rotating machines as per the relevant API Code. The speed governor shall be electronic type and have remote speed setting from the main panel and the central control room as well.

The system shall be digital governor suitable of providing an accurate speed control. The make of governor shall be Woodward model Micronet plus/505 with Dual modular redundancy. The governor shall be installed in the CR with serial communication to DCS.

The electro-hydraulic type converters for turbo machinery shall be Voith make only. Hazardous area classification of the field devices shall be suitable for plant hazardous area classifications. The required power supply to these units shall be fed from central cabinet room PDBs. Dual redundant 24 V DC bulk power supply for these systems, if required. These power supply units shall be installed in PDB located at central cabinet room and required power cables (with proper sizing and armouring) shall be laid in overhead cable trays/ducts between PDB and field devices.

The steam inlet and extraction valve shall be cam or bar lift multi valves to provide maximum efficiency for all turbine load conditions. Because of the well known wear and vibration problem with mechanical linkage system to those valves, special attention shall be paid to the design of these systems.

The points mentioned below shall be carefully observed when designing the control system.

The valves shall be positively held stems to prevent spinning, chattering and sticking.

Surface hardened stainless steel bushings shall guide the valve stems into lapped seats, sealing the valves against leakage. All linkage shall be external to provide greater accessibility and freedom to perform visual inspection. Each cam or bar shall be individually adjustable to give the desired rate of opening and to provide maximum efficiency during all loads.

External location of cams or bars and visible valve stems with position indication shall be foreseen.

4.2.2.8.4 Over-speed Trip Systems for Turbines

All the over-speed trip and monitoring system shall be implemented in latest Woodward/Protech/Braun make systems.
To protect the operating personnel and equipment, the turbine shall be equipped with an 2oo3 overspeed trip device that shuts down the turbine, when rotating speed exceeds the maximum speed by approximately 10 percent. The emergency governors shall operate totally independent of the normal controlling speed governor.

The whole over speed trip system ( 2oo3) shall be very carefully designed to ensure that the turbine will trip in all situations of over speed, especially the time lag in the mechanism shall be kept to a minimum, ensuring very fast operating of the trip and throttle valves. The trip valve shall be provided with a limit switch for indication of closed position (running light) in the central control room.

The following shall be provided as a minimum

- 3 Speed probe required for measurement & control – Latest Woodward system
- 3 Speed probes for 2oo3 trip.- Latest Protech/Woodward system

All Speed Probes shall be of Braun / Protech make.

2oo3 trip system shall be of Protech/Woodward only.

The system shall close not only the trip and throttle valve, but also steam admission valves.

A hand trip device for emergency manual tripping shall be located in front of the turbine where it is readily accessible. It shall be possible to verify trip set points while the turbine is coupled to the compressor.

The secondary hardware of these system shall be installed in central cabinet room in a standard RITTAL panel of 1200mm (W) x 800mm (D) x 2100mm (H) or 600mm (W) x 800mm(D) x 2100mm(H) with RAL7035 color shade.

A dedicated laptop for programming and back up of all machines’ wood word protech 2 out of 3 devices shall be provided along with required software/cable. The laptop shall be with latest Intel hardware, OS and MS office software at the time of supply.

4.2.2.8.5 Contractor shall be responsible to supply completely engineered, integrated, tested and ready for commissioning system with state-of the art control system for effective, safe and efficient operation of BMS unit. The complete package shall be supplied by the BMS VENDOR with only coordination activities carried out by contractor.

4.2.2.8.6 The type of the instruments and control system shall be as per the BMSVendor recommendations. However, contractor must ensure that minimum requirements specified herein with the client/pmc requirements are met. Contractor shall also ensure that the vendor list attached with the package is followed. In case of any deviation, contractor must forward the Vender recommended makes and models along with performance guarantee requirement of licensor specific for this project.

4.2.2.8.7 Contractor must note that BMS supplier shall be fully responsible for complete instrumentation including;
a) Supply of complete instrumentation for BMS unit including all field instruments, control valves, shutdown/cyclic valves, analyzers & control system (to be located remotely in Control Room), all installation materials, all interconnecting cables etc.

b) Supply of all field instruments duly mounted in the Boiler with wiring/cabling complete up to junction boxes. Local panel, if necessary, shall be supplied as part of the skid.

c) Design, engineering, integration, testing and supply of control system as per requirements.

d) Installation and integration of control system with field mounted skid. All interconnecting cabling shall be armoured type only.

e) Design, engineering, testing and supply of all analysers as per process package requirements either in a separate analyser shelter or in any other PLANT shelter if design conditions and requirements permit.

4.2.2.8.8 Contractor must ensure that BMS VENDOR Instrumentation and control system specialist is available at site during loop checking, integration and commissioning & Performance guarantee run of BMS units.

4.2.2.8.9 All the instruments within BMS unit shall be certified by the statutory authority for use in IEC Zone-I Gas group IIC.

4.2.2.8.10 BMS unit shall have a dedicated control system located in the control room. The control system shall be a programmable-based control system capable of handling sequence control and analog controls as per unit requirements. The main architectural features of the control system shall be in line with PLC datasheets & design basis.

a) The I/O testing shall run automatically in a predefined testing period and also shall be event driven (a mismatch of I/Os for analog inputs shall also be acceptable provided
- maximum no. of analog I/Os per module shall be four only.
- The maximum no. of control loops per module shall not exceed two(2).

c) The control system shall be supplied with two operating Stations (PLC consoles) each of which is able to operate and engineer the complete BMS unit independently. Both these consoles shall be interchangeable operationally.

The consoles shall have one nos. of LCD Displays with the following requirements:
- Both Console shall have full graphic capability and shall be configured with bms unit graphics.
- LCDs shall also be capable of operating in engineering mode.
- LCDs shall be supplied in a console mountable model such that these can be installed in any of the operator console.

d) The system shall be provided with dual serial links with RS-485 modbus specification. These links shall be used for linking BMS system with DCS.

e) BMS VENDOR shall provide all information on the data transfer to DCS so that the control system is interfaced with DCS seamlessly.

4.3 INSPECTION AND TESTING
REFER STD 9998 FOR INSPECTION AND TESTING.

4.3.1 All instruments and system oriented items shall undergo factory testing and inspection by contractors authorised representatives, PM, Owner / PMC, unless specified otherwise.

4.3.2 Wherever inspection at manufacturer's shop is waived because of any reason, the contractor shall carry out the inspection at vendor/sub-vendor's shop and Contractor shall forward these inspection reports for verification by owner/PMC before dispatch. In no case, items shall be released without proper inspection / verification.

4.3.3 The inspection and testing shall be carried out as per related specifications, international codes and practices/standards, approved documents and / or any other document attached along with specifically suggesting extent of testing to be carried out at manufacturer's works.

4.3.4 Items for which ‘Witness Inspection’ is specifically exempted, manufacturer shall forward the test certificates as desired for review. The material shall be dispatched only after obtaining written dispatch clearance.

4.3.5 No system or system oriented item shall be dispatched without integrated factory testing witnessed by representatives of contractor/ purchaser / Owner / PMC. The testing procedures shall be detailed out by contractor based on testing requirements indicated in individual system specifications and shall be approved by owner/ PMC. Contractor must certify that the system is actually ready before calling the Owner/ PMC for FAT. Also all the necessary documents & technical catalogues are to be submitted before calling for FAT.

4.3.6 Testing and inspection for all items shall be carried out as per approved factory testing procedures. For items where no testing is witnessed by the PM, following test certificates shall be forwarded for review before dispatch of such equipment:

a) Verification of certificates as applicable for the material certificates, NDT reports like radiography/ X-ray / die-penetration/ MP, special testing reports like cryo testing, IGC testing etc., statutory certificates (from CCOE/DGFASLI) for Intrinsic safety and explosion proof, certificates of conformity etc.

b) Visual verification for quantity, quality and workmanship.

c) Hydro testing and pneumatic testing as applicable.

d) Functional and performance testing including calibration, accuracy, repeatability testing.

e) Seat leakage tests & hydraulic Pressure test, actuator cycling & fail condition tests for control valves

f) Set pressure, reseat pressure & seat leakage for pressure relief valves.

g) Radiographic test for control valves, pressure relief valves, flow meter bodies, thermowell etc.

4.3.7 Contractor must detail out performance specifications of each item which shall be verified by contractor or contractor appointed agency / Owner / PMC during factory testing.

4.3.8 Deleted
4.3.9 Contractor shall submit all test records / test results for records to purchaser as bound volume along with the test procedure for each test carried out.

4.3.10 Contractor shall follow the Inspection and Testing Table attached along with INSPECTION AND TESTING TABLE for minimum testing requirements for instrument items.

a) The table indicates the summary of testing requirements of various commonly used instruments. Contractor shall detail out these requirements in order to ensure quality of instrument items.

b) Testing procedures shall be developed by contractor based on relevant codes, international standards and practices followed internationally for various items unless otherwise indicated separately.

4.3.11 Acceptable criteria for Radiography and other NDT requirements for all the instruments / instrument castings shall be inline with those specified in ‘valve / piping specifications’ for the similar service. Valve specifications/piping specifications have been attached elsewhere in this package.

4.3.12 IBR Certifications shall be provided by contractor in the appropriate format duly signed by IBR authority or their authorized agency.

4.3.13 All sub packages shall be tested with job control system and control panel, as far as possible.

4.3.14 CCOE/DGFASLI certificate shall be supplied by the contractor for all instruments installed in hazardous area.

4.3.15 For carrying out integrated factory testing of all system oriented integrated systems like DCS, BMS, PLC etc where many foreign device interfaces are also interfaced, contractor shall supply simulators for all foreign devices, which are in their scope of supply, at DCS/PLC vendor works along with their engineer during factory testing. A 100% checking of complete application shall be carried out for all foreign devices to ensure proper integration.

4.4 INSTALLATION, LOOP CHECKING AND COMMISSIONING

Instruments shall not be mounted on vibrating equipment

All instruments shall be installed in accordance with standards drawings provided and for new one the same shall be developed with approval of PMC / Owner.

4.4.1 INSTALLATION REQUIREMENTS

4.4.1.1 All instruments shall be accessible from grade or a platform for operation and maintenance. In case of gas services, where the instruments are mounted above the process tapping, installation of platform shall be considered if accessibility is not available. Ladders shall be provided for all such platforms. Approach for all instrument tapings shall be considered in all piping, other equipments and from platforms so that all instrument tapings are accessible.

4.4.1.2 Contractor shall consider the, “PMC installation standards “as attached or. Equivalent for installation of each instrument. In case, any instrument require a special installation or any instrument not provided with installation standard the contractor shall prepare the standard and get it approved by Owner / PMC along with other documents.
4.4.1.3  Impulse pipe of size ½” shall be used as impulse lines. The impulse pipe for instrument installation shall be as per the piping material specifications of respective process lines. Tubing when used between manifold and the instrument shall be 12mm OD with SS316 material of construction as a minimum. The material selected shall be suitable for the process fluid conditions.

4.4.1.4  Instrument in gas service are to be installed only above or at least parallel to the tapping with a slope in the impulse piping towards the tapping to achieve self draining condition.

4.4.1.5  Control valve/Pressure Relief valves, flowmeters etc. to be installed in line only after proper flushing of the lines.

4.4.1.6  For liquid service the instruments shall be installed below the taping points in general.

4.4.1.7  No unions shall be used in impulse lines instead break flanges shall be used.

4.4.1.8  Gate valves shall be used for isolation and vent & drain valves, however globe valves shall be used for equalising service.

4.4.1.9  Wafer seal instruments are to be used for congealing services.

4.4.1.10  Impulse piping are to be suitably painted.

4.4.1.11  Insulation of impulse lines shall be as per piping class.

4.4.1.12  Sch 80 seamless pipe with at least 3000 lb rating fillings should be used as a minimum for impulse piping.

4.4.1.13  For steam tracing of instruments copper tube 3/8" OD and brass fittings shall be used. Tube filling shall be double ferrule type.

4.4.1.14  The steam tracing installations standards attached along with this package are typical. Contractor shall develop the steam tracing standards in line with the above. All steam traps required for steam tracing of instruments shall have block and bypass valves for steam trap maintenance. These specifications shall be over and above those indicated in installation standards mentioned above.

4.4.1.15  Based on the installation standards for each type of instrument, contractor shall prepare Bill of materials (BOM) which indicates the requirements of different materials for installation of each instrument.

4.4.1.16  Use of standpipe for level instruments shall be as per licensor’s documents. The level tappings from the vessels and columns are not to be taken from the bottom.

4.4.1.17  Trays shall be fabricated as per standard approved by owner/PMC.

4.4.1.18  Cable trays shall be supported at the bottom longitudinally on both edges, throughout its length by means of MS channels (minimum 100 mm) to avoid sagging due to cable weight.

4.4.1.19  Cable tray laying shall take care of the necessary clearances for the fire proofing of the structures wherever provided.

4.4.1.20  Mounting of instrument (if remote mounted)/JB on the stanchion or instrument support shall be at the height of 1.3M from the grade level / finished floor level.
4.4.1.21 Extension in the impulse piping of suitable length may have to be provided for those instrument installations where process fluid temperature is higher than the maximum withstanding temperature of the instrument/diaphragm.

4.4.1.22 The installation and erection materials like, cables (signal, control, thermocouple extension and power), cable glands, junction boxes, instrument valves and manifolds, impulse pipe and pipe fillings, pneumatic signal tubes, instrument air line fittings and valves and cable trays/trays required for installation of complete instrumentation shall be as per specifications in standard specifications for instrumentation work enclosed in this package along with additional standards in this package.

4.4.1.23 As far as possible, the instrument tapping shall be located such that the instruments are approachable from the platform. If not, then the instrument nozzles should be provided such that common platform could be provided to service the number of instruments. Platforms shall also be provided on the pipe racks for approach to instruments.

4.4.1.24 The stack analyser probe should be at the lowest possible level and must have a suitable platform with it along with proper approach. The said platform should be connected with the furnace stack. The tapping points of the furnace analysers are to have clear approach for maintenance and opening of tapping flanges.

4.4.1.25 Wherever multiple transmitters being used, separate take off from shall be taken from the flange itself.

4.4.1.25 Instrument Air distribution

(Please refer design basis)

a) For instrument air distribution, Contractor shall bring the air supply line to a single point to various process unit battery limit and shall distribute further to the individual consuming points i.e. control valve smart positioners, actuators etc. Further distribution of air to all control valve smart positioners etc. using necessary piping, tubing, isolation valve and fittings shall be in Contractor’s scope. Adequate nos. of unions shall be used in instrument air line distribution. Refer to drawing attached. Contractor shall work out the air supply distribution as required and air supply distribution details shall be indicated in relevant instrument location drawing.

b) SS pipes and fittings shall be used for instrument air distribution from instrument air headers upto the instrument air isolation valves. Further distribution shall be by 6 mm SS tubes with SS tube fittings, air filter regulators etc. The connection of instrument air line to main air header shall be screwed and no welding is allowed.

4.4.2 LOOP CHECKING AND COMMISSIONING

4.4.2.1 Contractor is fully responsible for all work related to loop checking including cable laying, dressing, identification, ferruling, calibrations, loop testing in coordination with DCS vendor.

4.4.2.2 Before proceeding for loop checking the calibration results of individual elements shall be recorded on the Contractor supplied proforma which shall be approved by Owner) PMC for correctness of installation) measurements and calibration results.
4.4.2.3 For calibration of special instruments, loop checking and for loop checking of sub-vendor packages Contractor shall do necessary coordination with sub-suppliers. The Contractor shall carry out the necessary loop checking to the satisfaction of Owner / PMC which shall be part of Contractor's scope of work.

4.4.2.4 For special instruments like Analysers, Programmable logic controllers, steam turbine control system Anti-surge controllers sub vendors of compressor package etc contractor shall ensure the presence of suppliers, technical personnel during field testing/loop checking and during commissioning to assist in above activities.

4.4.2.5 The procedure as outlined in Part-II of (Testing, installation commissioning and acceptance of DCS system) shall be followed for loop checking and commissioning for example;

The procedure and scope of loop checking shall be as detailed below for the loops connected to DCS/PLC, LCP, etc. Contractor's scope is to lay single/multipair cables etc. upto the control room cellar area through Multi Cable Transit (MCT) blocks as per MCT vendor's recommendation (in contractor's scope), laying of all cables through MCT, laying of cables on trays, branching trays at cellar area till cabinets, tagging of all field cables, performing continuity/insulation test of cable, identification of all cables and cores and dressing, glands and terminations at both ends.

i) Calibration of all field instruments independently.

ii) Providing all assistance to control system sub-vendor during loop checking. This shall include providing signals from the field instruments and checking valve operation with respect to the output from control system to enable control system vendor to verify loop performance.

iii) Ensure proper Co-ordination with control system sub-vendor to meet loop checking schedule. It shall be contractor's responsibility to demonstrate/prove measuring signal levels of field instrument output in control room in the respective identified pair of cable, in case of any problem.

iv) Rectification/re-calibration of field instruments, if found defective during loop checking.

The termination of field cables, checking of interconnection between Instrument/equipments inside control room, ferring/tagging (follow cross-direct ferring concept) of interconnecting cables inside control room and performing loop checking with the co-ordination of contractor shall be in the scope of Contractor.

Loop testing shall be contrayed to check the functional performance of all elements comprising the loop, thereby ensuring proper inter-connections and operations.

Before proceeding for loop checking, the calibration results of individual elements shall be recorded on the contractors supplied proforma which shall be approved by PMC/Owner for correctness of installation, measurements and calibration results.

Loop testing for all control loops shall be generally by simulating process conditions for at least 0%, 25%, 50%, 75% and 100% of full scale inputs. Detailed procedure shall be submitted to PMC/Owner for approval before proceeding with the loop checking.

In case of shutdown systems, field/receiver switches are simulated for abnormality by disconnecting the wires at terminals and software alarms are simulated in DCS/PLC. Function of all associated systems are checked including performance of solenoid valves, On/Off type control/shutdown valves including proper functioning of limit switches and other accessories.
Adjustment of limit switches wherever necessary also form part of checking of loop performance.

Performance of individual loops shall be accepted for an overall accuracy of ±1.5%. Where deviation is found to exist more than specified limit, contractor shall re-calibrate the instruments which shall also form part of loop testing, without any implication.

After the loop test is complete, contractor shall connect back any terminations and connections removed for loop checking. Also, any bypass software or hardware, simulated signals, overrides etc. simulated during loop check shall be restored to normal state.

In case of loops in which instruments like receiver alarm cards, field receivers) switches are calibrated by control system sub-vendor, loop checking shall be performed in co-ordination with them. If a defect in the calibration of the instruments in contractor’s scope is observed, same shall be rectified by contractor to the satisfaction of PMC / Owner. If defect is detected in the calibration of the instruments in the scope of control system vendor, same shall be rectified by System vendor. After the calibration has been rechecked by control system sub-vendor, the loop checking would be performed to the satisfaction of PMC /Owner, which shall be part of contractor scope of work.

Contractor shall complete all entries in the ‘Loop Sheet related to field instrumentation including calibration, installation checks, interconnection of tubing and cabling, hydrotest etc. and get it signed by PMC /Owner. All loop sheets duly filled and signed shall be handed over to control system vendor for overall loop checking records.

The control system vendor shall complete the loop check column in loop sheet after acceptance of loops and hand over the sheets to PMC /Owner.

Contractor shall be completely responsible for simulation of the logics from the field by physically actuating the switches and generating the signals in case of transmitters. Simulation of interlocks shall be carried out by Contractor & the same would be witnessed by OWNER / PMC / Licensor. Necessary format shall be generated by contractor & the same shall be approved by PMC before carrying out the interlock simulation test.

**4.4.2.6** The sub package items like Machine Monitoring System, analyser system, etc., clause 4.4.2.5 is applicable. Contractor shall demonstrate the entire data signal at required location with specified accuracy. Contractor shall also coordinate with System vendors for system integration testing of the above.

**4.4.2.7** For items/systems/instruments which are free issued to contractor for installation, contractor shall satisfy the owner/respective vendor of proper installation and help them to complete loop checking calibration and commissioning. This include CCTV and Gas detection system.

**4.4.2.8** Complete loop checking of the systems and equipments being supplied by contractor or any item/cabinet located in rack room/control room shall be carried out by contractor.
4.4.3 SYSTEM ACCEPTANCE TEST

The owner will take over the system including (all systems oriented items like DCS/PLC, Analyzers, field instruments etc.) from the contractor after the final acceptance test attended by Owner/ PMC, which is defined as successful uninterrupted operation of the integrated system for three weeks for PLANT. Uninterrupted Operation shall be defined as follows:

- All field Instruments, analyzers, gas detectors, Machine protections etc shall be commissioned, fully operational & shall be proved as per process.
- All control schemes including Complex schemes shall be taken in Auto / cascade mode
- All controllers shall be optimally tuned for both normal & turndown condition.
- All interlocks shall be taken on line without Bypassing the interlocks
- All constants, timer values shall be configured as per licensor / OEM recommendations.

System Vendor’s personnel shall be present during the test. Any malfunctioning of the items supplied by the contractor shall be replaced / repaired as required. Once the system failure is detected, the acceptance test shall start all over again from the beginning. The warranty period commences from the day owner takes over the contractor supplied equipment.

4.5 CONTROL ROOM

4.5.1 The CONTROL ROOM shall house all the system Racks. It shall be totally new blast proof building and the same shall be in bidder scope.

It shall have clean agent room, battery room, Rack Room, UPS, HVAC.

Rack Room: Area where all cabinets, racks and panels like marshalling cabinets, barrier cabinets, system cabinets, power supply distribution cabinets, LEL panels etc. are located.

The cables upto the respective cabinets shall be routed from main trunk trays through feeder/branch trays in the false flooring upto racks in rack room.

4.5.3 Contractor shall be responsible for all control room and control room engineering / execution. This shall include but not limited to:

a) Generation of all inputs for control room layouts such as I/O listing, cable schedule, MCT layout finalisation, contractor supplied items to be installed in control room etc. for DCS system and other package vendor items, and finalise various layouts.

b) Laying of cables inside the control room in cellar area as defined elsewhere in branch on trays/ trays. The branch trays shall be provided by the contractor. Contractor shall finalise the sizes and the routing of trays and layouts before commencement of cable laying. The layout shall be prepared considering following cross-sections as a minimum:
   i) MCT blocks
   ii) Main Tray
   iii) Branch tray
Each cross-section shall show layout and cable no. covering all cables within their units.

c) Preparing details of cabinets such as dimensions, base frame details for providing base channels contractor and the installation of these cabinets.

4.5.4 Cable routing

Contractor shall consider the following:

Separation while routing shall be followed for various types of cables to ensure ease of cable installation and to protect the interference among the cables.

a) Signal Cables
b) System Communication cables
c) Power supply cables
d) Alarm cables
e) Shutdown cables

Separate route shall be followed for redundant cables. Also all the network cables/cables carrying serial signals.

4.5.5 Junction Boxes

Two numbers each of signal, contact & T/C spare JBs shall be installed for each unit PLANT & 1-12 and 1 multicable wired upto control room marshalling rack room. Location of JBs in the field shall be intimated during detailed engg.

4.5.6 Multicable Transit Blocks (MCT)

a) Contractor to note that the cable entry into cable cellar shall be through Multi Cable Transit blocks (MCT) only. The MCT shall be sized, supplied and installed at site by Contractor for PLANT entry. The minimum no. of size supplied by the contractor shall be as follows:

- Individual MCT block for different types of signals

The actual sizing shall be the responsibility of contractor based on the actual no. of cables. The sizing defines the minimum requirement.

Suitable cutout based on the sizes given with this specification for installation of MCT frames on the blast proof wall of control room shall be provided by contractor for MCT blocks. In case any additional entry or modified entry is required after the cellar wall is cast the same shall be taken care by of by the contractor.

The MCT entries shall be closed with a thick CS plate, which shall be removed by contractor whenever the MCT is installed.

b) The MCT frames shall be of standard RGB type of ROXTEX or equivalent and of steel construction. The supply shall be complete with insert blocks, spare blocks, stayplates, end packing etc. For flexibility in the engineering peel off sleeve’ type of design shall be used.
c) Contractor shall size the MCT considering 50% spare for each cable size /OD. In addition to installed spares, Contractor shall also provide 50% spare insert blocks in each cable size /O.D. as loose supply. All spare entries in the MCT block shall be plugged.

d) The power cables for instruments shall be suitably separated from the other cables and shall be routed through separate MCT blocks. In general, the MCT frame considered for instrument shall not be used for electrical cables.

e) The MCT shall be installed by contractor as per the recommended practice of supplier. No spare space shall be left uncovered in the frame.

f) The electrical power and control cables shall not be routed through instrument MCT's. If necessary separate MCT's may be used for the same.

g) For analyser shelter MCT sizing /supply shall be carried out by the contractor based on (b) to (e) above.

4.6 ANALYZER SHELTER

Refer JOB STANDARD SPECIFICATION for analyser shelter.

4.7 PACKAGE UNIT INSTRUMENTS

Refer STANDARD SPECIFICATION FOR PACKEG UNIT

Instruments and controls for Cooling Tower, Effluent Treatment Plant, etc shall be in general standalone type dedicated Electronic microprocessor based control system. Normally all controls shall be possible from Local control panel. For utilities like power supply, water, and instrument air shall be provided at the battery limit. Instrument types and models shall be standardised across the plant.

Local Control Panel shall be stand-alone type and suitable to be interfaced to the main DCS through a serial link RS 485 MODBUS RTU protocol, (DCS shall be the master and UCP the slave), to transfer data and alarms.

The Safety systems shall operate independently of the control system. Shutdown signals between the LCP and the Plant ESD System shall be hardwired.

A plant ESD may require the Package to be shutdown during a process upset condition.

Equally, the Package LCP may need to signals the plant ESD System that it has shutdown due to process upset conditions within the package. These signals shall be distinct and separate.

The level of this interface will depend on the Shutdown Philosophy and shall be developed during the Detail Design.

As a minimum the Package LCP shall allow the DCS operators to change set points, starting, stopping of motors, fans etc.
Microprocessor based control systems for packages shall be fully functional and operational in a safe mode even without interface to the plant DCS/ESD systems. The LCP shall be able to fully control of the Package in safe manner.

The systems chosen will be modular so that fault-finding at electronic module level will be minimal, utilising high levels of auto-diagnosis.

**Package Vendor’s scope supply includes:**

Instruments for safe and efficient running of the plant/machine. The supply shall include control valves, suction and discharge auto block valves, relief valves, shut off valves, solenoids, speed indicators, transmitters, pressure and temperature gauges, switches, sensors etc.

Alarm system, safety interlock system, motor alarms, machine monitoring and protection system if any shall be housed in central control room.

Gauge Board to be located near each machine with local gauges mounted on it

All instrument erection materials such as cables, pipes, pipe fittings, supports, trays, conduits, junction boxes etc.

Tools for service calibration and maintenance

Spares parts for 2 yrs. operations

Consumable for one year

Engineering documentation

**Process Alarm, Motor Alarm and Shut down System**

**General**

Critical alarms and shut downs must be derived from direct process sensors and shall be entirely separated from any other system (including process connection). All trip alarms shall always be preceded by a passive alarm from an independent primary measurement. However, the same primary element can be used for measurement of vibrations and displacement. No critical alarm sensors shall also be independent of shut down sensors, but may be common with sensors used for control or indication. Filled temperature elements shall not be used. Alarm signals from analog loops shall be derived via a trip amplifier. Inputs from thermocouples shall be provided with cold junction compensation and downscale burns out feature for high temperature shut downs and vice versa for low. a passive alarms shall warn about the burn-out.
The alarm and shut-down system shall be fail safe type and utilising field contacts that open in alarm conditions.

The logic for alarms (process and motor) and the logic for shut down system shall be independent.

A common output contact for the process alarm and motor alarm system for remote indication shall be provided. The contact shall be potential free and suitable for low level signals, i.e. gold plated. All alarms shall be integrated with DCS. The current trends for critical motors shall be available in the DCS.

**Physical Description**

The process alarm and motor alarm systems shall be supplied with displays, logic and power supply as an integrated package for flush mounting on the main panel front. Alarm facias may be separated from the electronics by prefabricated cables.

The shut-down system shall be shown in a logic graphic display on Mosaic Display on the main panel front containing the various trip alarms, by-pass lamps and switches, including open and closed positions of any automatic block valves. The logic and duplicated power supplied shall be located inside the panel.

The internal power packs shall have an output of 24V/DC, full wave rectified, generated from the 11VAC supply.

The annunciator sequence for process alarms shall be ANSI/ISA-SI8.1, Type “A-14”.

**Monitoring and Protection of Compressor/ Machines**

For the purpose of monitoring the “health” of the machine and for automatic shut-down in case of emergency, a highly reliable continuous Machine monitoring system shall be supplied for Vibration, Axial displacement, Thrust, Overspeed, Key-phasor etc..

The monitoring system comprises machine mounted sensors and transducers and the monitoring instruments installed in the main panel in the local control room. The complete system shall be from M/s Bentley Nevada, in order to have single source system responsibility.
5.0 MANDATORY SPARES

Refer attached Mandatory Spares.

a) Contractor shall supply all spare instruments and Instrument spare parts as per the mandatory spares list attached elsewhere in this tender document.

b) The list covers only the generic names of various spares/spare parts. Contractor shall co-relate the same with the actual instrument/system being supplied. In any case, contractor shall not delete any spare part/spare instrument from the mandatory spare list attached with this package.

c) The instruments which are covered under this contract but don’t appear in the mandatory spare list, contractor shall prepare a list of spares and forward to owner/PMC for review.

d) The mandatory spare list shall be forwarded by the contractor for owner/PMC reviews as a separate document. The document for each instrument shall contain a mandatory spare format and the published part list document with highlighting spare parts being indicated.

The mandatory spare format shall contain the following formats:

- Instrument details like Tag number, Type of Instrument and data sheet number
- Serial number
- Spare part name/part number
- No of spare parts per instruments
- Total no of Instruments
- Total no of spare parts required
- Total no of spare parts offered

The format shall be completely filled and contain all the information duly filled in the format attached.
### CONTRACTOR DATA REQUIREMENTS

#### Drawing and Documentation

**INSTRUMENTATION**

List of Deliverables of the LSTK Contractor. shall comprise of but not limited to the following:

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<th>Description</th>
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<th>For Information</th>
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<td>32</td>
<td>Complete catalogues with part list for all vendor supplied instruments, control etc.</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>33</td>
<td>Installation, operation &amp; maintenance manuals</td>
<td></td>
<td></td>
<td>✓</td>
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<tr>
<td>34</td>
<td>As Built Drawings</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>35</td>
<td>Wake frequency calculation shall be carried out for thermo wells comes under two phase flow</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

NOTES:

(1) This list indicates the minimum drawings and documents requirements. However vendor shall submit complete list of document & drawing schedule listing all drawings and documents to be submitted by them during the course of execution of the job. The schedule shall list all drawings and documents along with their number and expected date of submission.

(2) As spelt out elsewhere in the Bid, Review / Approval / Information requirements of PMC, & Owner shall be intimated separately for the above documents, later.
STANDARD SPECIFICATION

FOR

ANALYSER SHELTER
Instruction to the Bidder

1. The Vendor shall submit complete Analyzer shelter GA drawings, BOM, HVAC details, BOM etc.

2. The construction of each analyzer house shall be prefabricated in press-formed stainless steel sheet. The materials of construction shall have a fire resistance of two hours minimum in accordance with UL 555 and NFPA Standard 90A

3. Seller shall supply the **complete redundant air conditioning, venting, heating and/or house pressurization system**

4. ORDER OF PRIORITY
   A) Instruction to Bidder
   B) Design Philosophy
   C) SHELTER SPECIFICATION

   In case of conflict, it shall be brought to notice of PDIL / OWNER for conflict resolution.
CONTENTS

1.0 GENERAL
2.0 DESIGN AND CONSTRUCTION
3.0 NAMEPLATE
4.0 INSPECTION AND TESTING
5.0 UTILITY SERVICES
6.0 SAFEGUARDING SYSTEM
7.0 ELECTRICAL UTILITIES
8.0 DOCUMENTATION
9.0 PACKING AND SHIPPING
10.0 SERVICE AND SUPPORT
11.0 SPARES
12.0 SHIPPING
Abbreviations:

AARH  Arithmetic Average Root Height
CMRI  Central Mining Research Institute
DCS   Distributed Control System
DPDT  Double Pole Double Throw
Deg C  Degree Centigrade
ERTL  Electronics Regional Testing Laboratory
NPT   National Pipe Threads
AMS   Analyzer Management System
ESD   Emergency Shutdown System
FAT   Factory Acceptance Test
HVAC  Heating Ventilating & Air Conditioning
PLC   Programmable Logic Controller
SAT   Site Acceptance Test
SCS   Sample Conditioning system
UPS   Uninterruptible Power Supply
1.0 GENERAL

1.1 Scope
The main purpose of an analyzer house/shelter is to ensure continuity of safe operation of analyzer systems at a specified rate of reliability by providing a suitable operating environment for analyzers which cannot otherwise operate properly, i.e. if exposed to outdoor or ambient conditions, the operating environment may be affected by requirements concerning

• Outside Area Classification EX. PROOF ZONE-2 GR IIC T3
• Inside Area Classification EX. PROOF ZONE-1 GR IIC T3
• Environmental conditions, mainly temperature and humidity
• Sample handling and conditioning
• Effective maintenance

Hazardous situation arising from the toxicity of gases and vapors which have to be handled shall be the subject of a special study, on the basis of which the appropriate measures shall be decided on and submitted by Seller to client for approval

The following measures are necessary to ensure the safe conditions in the Analyzer house:
• The quantity of flammable materials retained in the analyzer house shall be kept at minimum.
• An efficient ventilation system shall be provided to continuously dilute any internal release of flammable gas or vapors, in order to reduce the concentration at all time below 20% of the lower explosion limit.
• The provision of safe disposal arrangement for samples.

SCOPE OF SUPPLY

WORK INCLUDED
Analyzer house seller shall be responsible for the design, fabrication, construction and commissioning of each house. The house shall be delivered as a fully assembled analyzer house complete with all monitoring equipment, sampling systems, calibration gas supports, tubing, The electrical equipment, fire and gas detectors, alarm beacons, annunciation panel, safe guarding system and HVAC equipment in place, wired and connected.

For Field mounted analyzers, Seller shall be responsible for the design, construction and commissioning of shelter along with the sample conditioning system, sample lines including sample probes and test or calibration gases.

The analyzer house seller shall be responsible for the supply of all associated auxiliary equipment that will be mounted remotely from the analyzer house and for field mounted analyzers.

The analyzer house seller shall supply all the necessary calibration gas cylinders for each analyzer.

Seller shall be responsible for the installation and commissioning of Analyzer Management System along with all necessary hardware in analyzer house, SRR and Central Control Building (CCB).
STANDARDS

1.1.1 This specification, together with the data sheets covers the requirements for the design, materials, nameplate marking, inspection, testing and shipping of analyzer shelter with HVAC system complete with accessories, which are required for housing industrial process analyzers and their associated piping, wiring and auxiliary instruments.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry:

- ANSI/ASME American National Standards Institute American Society of Mechanical Engineers.

- B 1.20.1 Pipe Threads General Purpose (Inch)

- ANSI/ASME B 31.3 Chemical plant & Petroleum refinery piping

- B 16.5 Pipe Flanges and Flanged Fittings NPSY2 through NPS24

- B 16.20 Metallic Gaskets for Pipe Flanges, Ring Joint, Spiral wound and Jacketed.

- EN 10204 Inspection Documents For Metallic Products.

- IEC-60079 Electrical Apparatus for Explosive Gas Atmosphere.

- IEC-60529 Degree of Protection Provided by Enclosures (IP Code).


- IEC-61511 Functional Safety instrumented system for the process industry sector.

- IS-13947 Specification for Low Voltage Switch gears and Control gears.


- IS-2148 Electrical Apparatus for Explosive Gas Atmospheres-Flame proof Enclosures d'.

- IS-5780 Intrinsically safe electrical apparatus and circuit electrical equipment with type of protection 'i'.

- NFPA496 National Fire Code

- API RP 540 Electrical Installations in Petroleum Processing Plants

- API RP 551 Process Measurement Instrumentation

- API RP 552 Transmission Systems

- API TP 555 Process Analyzers
NACE MR-01-75 Sulphide Stress Cracking Resistance Metallic Materials for Oil Filled Equipments

ASTM A269 Seamless Welded Austentitic Stainless Steel Tubing For General Service

C15 Procedures for Cylinder Design Proof and Service Performance Tests

IEC 60079-016 Electrical Apparatus for Explosive Gas Atmosphere Part16
  – Artificial Ventilation for the Protection of Analyzer houses

NEMA ICS6 Industrial Control and System Enclosures

NFPA Standard 90A Two hour fired rated

NFPA 496 Standard for Purged and Pressurized Enclosures for Electrical Equipment

BS 476 Test on Building Materials and Structures

BS 3463 Observation and Gauge Glasses for Pressure Vessels

IS 2147 Degree of protection provided for enclosure

IS 2148 Flameproof enclosure for electrical apparatus

IS 875 Part (3) 1987 Indian Wind Code

IS 5771 Guide for the Selection of Electrical Equipment for Hazardous Areas

IS 5572 Classification of Hazardous Areas (other then Mines) having Flammable gases and vapours for Electrical Installations

EEMUA (Engineering equipments and Material User Association) – Design and Installation of On Line Analyzer System

IS 5572 Classification of Hazardous Areas (other then Mines) having flammable gases and vapours for Electrical Installations

UL 555 Fire and Smoke Dampers

1.1.3 In the event of any conflict between this specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:
  a) Statutory Regulations
  b) Data Sheets
  c) Standard Specification
  d) Codes and Standards
1.1.4 Purchaser's data sheets specify the minimum acceptable materials. Alternate superior material for construction shall also be acceptable provided vendor assumes complete responsibility for the selected materials for their compatibility with the specified operating conditions.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition.

1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:

a) Compliance to the specifications.

b) Whenever the requirement of detailed specification sheet for analyser shelter is specifically indicated, a detailed specification sheet for each analyser shelter shall be furnished, which shall provide all the details regarding type, material of construction as applicable. The material specifications and the units of measurement for various parts in vendor's specification sheet shall be to the same standards as those indicated in purchaser's data sheet.

c) Proven references for each offered analyser shelter inline with clause 1.2.3 of this specification.

d) General arrangement / Layout drawing of each shelter.

e) List of utilities with expected consumption of each shelter.

f) A copy of approval from local statutory authority, as applicable, such as Petroleum and Explosive Safety Organization / Chief Controller of Explosives (CCE), Nagpur or Director General of Mines Safety (DGMS) in India, for the electrical and electronic equipments installed in electrically hazardous area along with:

i) Test certificate from recognized test house like CMRI/ERTL etc. for flameproof enclosure/intrinsic safety, as specified in the data sheet, as per relevant standard for all Indian manufactured equipments or for items requiring DGMS approval.

ii) Certificate of conformity from agencies like LCIE, BASEEFA, PTB, CSA, FM, UL etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

g) Deviations on technical requirements will not be entertained. In case vendor has any valid technical reason, they must include a list of deviations tag number wise, summing up all the deviations from the purchaser's data sheets and other technical specifications along with the technical reasons for each of these deviations.
h) Catalogues giving detailed technical specifications, model decoding details and other related information for each type of analyser shelter and other equipments / instruments covered in the bid.

1.2.3 All items, as offered, shall be field proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date in the process conditions similar to those specified in the purchaser's data sheets. Items with proto-type design or items not meeting proveness criteria specified above shall not be offered.

1.2.4 All documentation submitted by vendor including their quotation, catalogues, drawings, installation, operation and maintenance manual etc. shall be in English language only.

1.2.5 Vendor shall also quote for the following:

a) Unit rate of any special items.

b) Any special tools and tackles needed for maintenance work. In case no special tools are necessary for maintenance for the offered shelter, vendor must certify the same in their offer.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of reproducible, prints and soft copies shall be dispatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual etc. submitted by vendor after placement of purchase order shall include the following, as a minimum:

a) Specification sheet for analyser shelter and its accessories.

b) Certified drawing for each analyser shelter, which shall provide following details;

   i) Overall / Mounting Details of the complete shelter in millimetres
   ii) Clearance space required for maintenance work.
   iii) Schematic diagram for the complete assembly including utilities required for the shelter.
   iv) Heat load calculations and dehumidified air flow rate calculation.
   v) LEL level of gases present with calculation for safe limit dilution of inside shelter air.

c) Copy of type test certificates

d) Copy of the test certificates for all tests indicated in clause 4.0 of this specification.

e) Installation procedure for analyser shelter.
1.4 Definitions

1.4.1 Analyser Shelter

Enclosed prefabricated building or part of a building containing process / stack analysers and associated equipment where streams for analysers are brought in and which is regularly entered by authorised personnel for operation and maintenance.

1.4.2 Analyser Shed Structure with one or more sides open and free from obstruction to the natural passage of air, in which one or more analysers are installed. The maintenance of the analyser is normally performed in the protection of the shed.

1.4.3 Analyser rack
An open analyser mounting structure with / without canopy used for mounting analysers, sample handling system and their accessories individually or together in combination.

1.4.4 Analyser cabinet
Small housing in which analysers are installed individually or grouped together. Maintenance is performed from outside the cabinet with door(s) open.

1.5 LOCATION AND SIZE OF ANALYZER HOUSE

In general, Analyzer house shall be located in Non-hazardous area. Where this is not possible, the highest area classification acceptable for the location of an analyzer house shall be Zone 2.

Analyzer house and field mounted analysers shall be located as close as practically possible to their relevant sample points in order to minimize sample transport lag and prevent sample degradation. Analyzer house location under pipe racks or other structures shall be avoided.

Additional to the requirements of IEC 61285, the location of analyzer house or shelter
• Shall be at least 15 meters away from furnace / reactor.
• Shall be such that the vibration level does not exceed that specified for the equipment accommodate inside the analyzer house
• Shall be free from spills of water and process liquids

Seller shall size each analyzer house. The analyzer house size shall take into consideration the size of each analyzer plus an allowance for 30% spare on both inside and outside walls for future analyzer and sample conditioning systems. Analyzers shall be installed along the longitudinal walls of each house; they may be mounted on the wall, using ‘Unistrut’ or equal or on free standing racks in such a way that all parts are freely accessible for maintenance. The analyzers shall bear clear identification plates stating their service. The preferred analyzer house sizes are listed below, seller to select the best suited for the application:

• TYPE 1 – 3m(L) x 3m(W) x 2.8m(H)
• TYPE 2 – 4m(L) x 3m(W) x 2.8m(H)
• TYPE 3 – 6m(L) x 3m(W) x 2.8m(H)
• TYPE 4 – 8m(L) x 3m(W) x 2.8m(H)
• TYPE 5 – 10m(L) x 3m(W) x 2.8m(H)

The minimum walk space between fixed obstacles should be 1 meter taking into account the constraint that cabinet doors may be locked in the open position on one side. There shall be sufficient clearance between cabinets and equipments to allow for maintenance access. Sufficient space shall be provided inside the analyzer house for installation of sink, work bench and auxiliary equipment such as control units and if required recorders, signal converters, printers, computer terminals, etc.

2.0 DESIGN AND CONSTRUCTION

2.1 General requirements

• The construction of each analyzer house shall be prefabricated in press-formed stainless steel sheet. The materials of construction shall have a fire resistance of two hours minimum in accordance with UL 555 and NFPA Standard 90A. The material shall be resistant to attack from oil and chemicals and other environmental factors such as high humidity and solar radiation, etc. All fittings, supporting framework, cable trays etc. shall be compatible with the house construction to minimize corrosion. Seller shall indicate their proposed type of construction in the offer.

• When the house structure is used for equipment support, there shall be sufficient rigidity to minimize vibrations. If required, anti-vibration pads and flexible pipe connections shall be used to isolate vibration sensitive equipments from the pipe work or structure.

• Each analyzer house shall have unobstructed internal headroom of at least 2.5mtr. Dead corners, trenches and spill or drain pits that may collect gases are not allowed inside the house.

2.1.1 The analyzer shelters are provided for housing industrial process analyzers and their associated piping, wiring and auxiliary instruments. The analyzer shelters are designed:

   a) To create a space within a hazardous area (Zone-I) in which under normal operating conditions a non hazardous atmosphere exists, so that testing or calibration of analyzers and maintenance can be performed with opened casings and electrical circuits alive.

   b) To create a controlled environment in which analyzers and their associated equipment are adequately protected against adverse weather conditions.

2.1.2 The analyzer shelter shall be fully prefabricated, assembled, tested and shall be supplied as ready-to-install at project site with all items including analyzers and the accessories duly mounted, wired, tubed and tested before shipment.

2.1.3 The arrangement of equipments shall be such that it provides enough access to front/back/sides of the equipments as necessary during normal operation as well as during start up and maintenance. Sufficient space shall be provided for workbench, signal and power cables entries and routing, power sockets, utility supplies, auxiliary and control equipments. Suitable arrangements shall also be made for locating devices like recorder, portable printers etc. near each equipment.
2.1.4 Shelters shall be equipped with all safety measures like panic bar at the doors, Emergency alarm push buttons, LEL gas (hydrocarbon) detectors, Fire detection system, warning panels, Fire extinguishers, wash basin etc.

2.1.5 Shelter shall be provided with ventilation and air-conditioning to maintain the temperature and humidity suitable for the analyzers stable performance, maintenance and human comfort.

2.1.6 Shelter shall be provided with both internal and external lighting for proper operation and maintenance.

2.1.7 All electrical equipments, fittings, fixtures shall be Flame proof suitable for hazardous area classification.

2.1.8 Analyzer shelter shall be sized considering 30 % additional spare space and facilities like HVAC load, power load etc. for future use.

2.1.9 The design shall be in compliance with the electromagnetic compatibility requirements as per IEC 61000-4.

2.1.1 Design Consideration

Analyser house design calculations shall be based on the following loads:
• Dead load including weight of analyzers, analyzer house, HVAC equipments, and all other equipments forming the part of installation
• Fixtures for HVAC equipment
• Transport loads (Vertical & Horizontal)
• Live loads including furniture & analytical equipment trolley, etc.
• Roof live load and concentrated loads
• Wind & rain loads
If straightening or flattening is required, it shall be accomplished in a manner that will not damage the material or detract from its appearance

WALL
The External walls of Analyzer house shall be fabricated from 2mm thick Stainless Steel sheet. All mating joints shall be fully welded and fixed by welding to a main support frame and each section to have gussets welded in position.

The Interior walls of Analyzer house shall be of a smooth design and fabricated from 1.5mm thick Stainless Steel sheet. The inner wall panels may be riveted in place provided that the panels are suitably sealed against the framework and that the floor is continuously extended vertically at the walls to provide a continuous skirting 150mm high (not at doors).

Each analyzer house shall have mineral fiber insulation (UL Approved for fire resistant construction) sandwiched between the inner and outer walls to meet the 2 hour fire rating. The insulation shall have a minimum thickness of 75mm. Asbestos or other hazardous material for insulation shall not be used. Seller shall consider the use of stiffeners between cavities. Seller shall ensure that gas or liquid cannot build up within the cavity.

Additional wall supports shall be provided as required to adequately support all wall mounted
equipments. Equipments shall be mounted using supports bolted to the inner wall.

**ROOF**

Analyzer house roofs shall be constructed of the same material as the main house (stainless steel) and be insulated. Houses shall have a centre pitch for rainwater drainage, complete with gutters and down pipes and designed to withstand uniform loadings at 0.75kMN/m2. The rainwater drainage system shall be sized to cope with the rainfall of 61mm/Hr and 522mm/24Hr.

Roof and ceiling panel shall be made of 18(1.3mm) gauge stainless steel sheet as minimum.

Roof shall be flat type with minimum practical slope of 25mm per meter.

Roof panels shall provide a net overhang of 300mm on all sides. The analyzer house shall have a canopy along each side of the house to protect external equipments. They shall be designed to withstand a wind speed of 50m/s. This canopy shall be “free venting”.

Roof panel joints shall be interlocked in such a way to provide a complete watertight fit.

**DOORS**

Analyzer house door shall be constructed of the same material as the main house (Stainless Steel).

Each analyzer house shall have outward opening doors at both the ends. One door shall be used as main entrance and other shall be used as Emergency exit. The minimum dimensions for both the doors shall be 900mm wide and 2100mm high. It shall be possible to remove all analyzers or other equipments installed inside the house through main entrance without disassembly.

Doors shall be hung on three recessed stainless steel butt hinges and fitted with weather strips. Each door shall have suitable gasket to prevent ingress of air, rain, etc. and loss of conditioned air and heat.

Each door shall be fitted with a panic bar and self closing spring system. Two hour fire rated double glazed viewing panels shall be fitted on each door, constructed from shatterproof safety glass and installed with suitable gaskets. Each door shall have lock with a master key for main entrance.

Both the doors shall be fitted with limit switches which shall initiate an alarm if left opened for longer than 30 Seconds.

**FASTENERS**

Bolts, nuts, and washers for structural connections shall conform to ASTM A325, and shall be hot dipped galvanized. Prior to final bolting, all galvanized A325 bolts shall be lubricated.

All sheet metal and/or self-tapping screws, self-drilling screws shall be Class 410 stainless steel.

Fasteners which penetrate the wall or roof covering shall be installed with a neoprene washer under the head.

**FOUNDATION & MOUNTING**

Each analyzer house will be mounted on a concrete base which shall be impervious to hydrocarbons (supplied by Client). Seller shall use fully welded Durbart floor plates (or equal). The floor shall be coated with a durable anti-skid, acid resistant epoxy coating on wear surfaces. The floor of the
analyzer house shall slope to the door(s). The doors shall not have an entry lip. This will allow any spillages to be swept out of analyzer house.

The Supplier shall supply detailed drawing mentioning the location, alignment and size of the anchoring bolts.

There shall be no openings at the base of the Analyzer House, including around support members.

The Analyzer Shelter shall be designed with provisions for a building-to-foundation seal after installation upon the concrete slab or structure.

The base of the Analyzer Shelter shall be minimum 6 inches (150 mm) deep steel channels and/or beams, which will also serve as the skid for shipping.

The skid frame shall be designed to support the Analyzer House with all the equipment while being lifted.

The skid shall be designed so that it is flush on all sides with the outside walls of the Analyzer House. The joints between the sidewalls and the base shall be sealed.

Lifting of each analyzer house shall be by Seller specified “eye-bolts”, mounted on each analyzer house roof, at suitable locations and sized to take load of analyzer house fully fitted with all equipments. If any special equipment such as Spreader Bar is required, they shall be supplied by House seller.

PAINTING
After primer has cured, two finish coats of epoxy resin, fire retardant paint shall be applied. The surface preparation and painting shall not be carried out until all welding is complete, including all brackets, mounting plates, etc. Surface finish should be applied to all external and internal surfaces including surfaces that will be enclosed with the double skin.

ALYZER SHELTER
The analyzers which are not mounted in Analyzer house shall be installed in a Shelter.

Shelter shall be provided with its own lighting and local switch mounted outside of the shelter certified for use in the hazardous area in which it is located.

The power isolation switch for each analyzer installed inside the shelter shall be supplied by Seller.

There shall be main power isolator switch mounted outside the shelter suitable for the area classification.

Shelter shall be so designed and constructed to allow free ventilation such that equipment contained within them can be certified the same as the area classification.

2.2 Construction
2.2.1 The shelter shall be constructed using materials capable of satisfying all the functional requirements and shall not create any safety hazards.

2.2.2 The design and construction of the shelter shall be self-supporting type and shall be sized to house required analyzers, their sample conditioning system and other accessories. Shelters shall also be provided with suitable transportation arrangement.

2.2.3 The base structure of the shelter shall be constructed using suitable size T beams, channels, and angles, welded properly and adequately. All structural members shall be sized to ensure structural rigidity and to prevent deformation during dragging, lifting, loading and unloading operations of the shelter.

2.2.4 The floor shall be fabricated from anti slip and non-corrosive Aluminium plates as a minimum, strong enough to withstand load of all equipments and at least I O-maintenance personal. It shall also be unaffected during transportation and various other obvious forces and shall be sealed to prevent any loss of ventilation pressure.

2.2.5 External sidewalls shall be ribbed interlocking stainless steel sheet of thickness 2mm and internal walls shall be stainless steel sheet of thickness 2mm. The walls of the shelter shall be strong enough to take load of the rack mounted analyzers, related sample conditioning system and associated accessories.

2.2.6 The shelter roof shall be capable of supporting the combined weight of at least 4 men without permanent deformation and shall be sealed properly to prevent loss of ventilation pressure and entry of rain and jet water.

2.2.7 Lifting of the complete shelter along with all analyzers, sample conditioning systems and associated accessories mounted in it shall be assured by means of suitably designed lifting lugs.

2.2.8 The walls and roof shall be insulated by using glass wool of high density and low thermal coefficient, of adequate thickness commensurate with the HVAC design.

2.2.9 The shelter shall be provided with a main door and an emergency door opposite to main door. Both the doors shall be opening outwards, provided with wire reinforced safety glass window, automatic spring door closer opening by simple push, fitted with panic bar for use in case of emergency. The main door shall be provided with outside pad lock holes. Warning light shall be provided at both the Main door and the emergency door indicating the Hydro carbon presence within the shelter.

2.2.10 Extension roof (overhang) made of stainless steel sheet shall be provided all along the walls of the shelter and over the sampling system for protection of the sampling system and maintenance personal from the direct weather conditions. The extension roof shall be overhung at least 1000 mm outside the analyzer shelter.

2.2.11 A nameplate with the analyzer shelter number shall be fixed near the main door and emergency door. Tag numbers of the analyzers shall be fixed near the main door. Tag Numbers of each analyzer and sampling system shall be fixed near the respective items. All inlet & outlet tube/pipes shall be provided with tag number & proper identification numbers engraved in the stainless steel plate. All electrical wires/leads shall be identified inside the junction box/equipment by proper plastic ferrules. All cables shall be identified with stainless steel plate engraved tag nos.
identification numbers.

2.2.12 Provision shall be made for keeping all fast loop devices, distribution devices outside the shelter. A suitable restriction orifice shall be provided in each sample line to limit the sample flow not exceeding thrice the normal flow in the event of tube rupture/opening of the tube down the line.

2.2.13 All pipes which introduce flammable gases inside shelter shall have readily accessible shut off valves.

2.3 Safety considerations

2.3.1 Analyser shelter shall be provided with pressurisation/purging with fresh air with air changes as per specs to make it safe for installation, operation and maintenance of analysers.

2.3.2 All junction boxes and electrical equipments shall be explosion proof as per area classification.

2.3.3 All analysers installed shall be suitable for working as per inside area classification even without fresh air purging / pressurisation.

2.3.4 The equipments which are not suitable for inside area shall be de-energised in case of ventilation failure and gas detection.

2.3.5 Warning panels, alarm annunciator, and repeat contacts to control room shall be provided for safety related parameters.

2.3.6 Gas detection, fire detection and oxygen deficiency detection shall be provided as per specs.

2.3.7 A PLC shall be provided to execute safety logics. PLC shall have redundant CPU. PLC shall be mounted in Ex-proof enclosure. PLC fault shall be annunciated.

2.4 Warning Panels

2.4.1 The following safety related local alarms / indicators shall be generated and displayed:
   a. Ventilation failure
   b. Flammable gas detected (> 20%)
   c. Fire detected
   d. Oxygen deficiency
   e. Gas detection Instrument fault
   f. Manual emergency (panic)

2.4.2 These alarms shall be supported at the following locations:
   a. Inside shelter on annunciator panel
2.5 Hazardous Area Classification

2.5.1 Hazardous area classification shall be as indicated in the job specification ~or outside the shelter. Hazardous area for inside the analyser shelter shall be considered as IEC Zone-I Gas Group IIC, temp. class T3 considering pressurization failure condition. All equipments inside the analyser shelter shall be suitable for operation in area classification under pressurization failure condition.

2.5.2 Non explosion protected equipments will be de-energised in case of pressurisation failure and gas detection.

2.5.3 Restart of such equipments shall not be possible without appropriate authorization.

2.6 HVAC System for Analyser Shelter

VENTILATION AND AIR CONDITIONING

GENERAL
- The purpose of ventilation and air conditioning system is to provide
- A safe operating environment for equipments and personnel
- The required climatic conditions for optimal equipment performance
- A sustainable climate for the comfort of personnel in line with local regulations and/or practice
- To dilute flammable or toxic gases and/or vapors that may accidentally escape from equipment inside the analyzer house to a non-hazardous level around any potential means of ignition
- To keep house pressurized to prevent possible entry of flammable or toxic gases from the outside atmosphere into the house
- Seller shall supply the complete redundant air conditioning, venting, heating and/or house pressurization system. The system shall be capable to maintain the inside house conditions as mentioned below:
  - Temperature 24°C ± 2°C
  - Pressure 5 – 10 mmwc
  - Humidity 50% RH ± 5%

Suitable temperature and pressure indicators shall be provided inside the house by Seller. Pressure switch shall be provided to initiate an alarm on loss of house pressure.

Each analyzer house shall have common fresh air intake via a stack mounted on the analyzer house roof. These stacks shall be provided with a rain hood and a mesh to prevent entry of birds etc. also adds tie bars for support of stack. The air shall be drawn from a non-hazardous area and the air intake location shall be at least 1 meter outside the hazardous area. The design of the intake duct and the diameter and length shall be sized by Seller so as to limit the air velocity inside the ducting to a maximum of 8m/second. The intake stack shall have filters 5 microns down to 99% efficiency, fire dampers and louvers.

All duct penetrations through fire rated walls shall include fire and gas dampers manufactured and
installed in accordance with the requirements of UL 555 and NFPA Standard 90A.

The dampers Shall have a two hour fire rating and shall spring close tight when released by a fusible link or by a Fire and Gas signal. The direction of the air flow within each house shall ensure air movement throughout, and around all equipment installed inside, irrespective of wind direction and strength.

The inlet ducting shall be fabricated from hot dipped galvanized steel to BS729, the size of the ducting shall be such that air velocities inside will not create noise level which exceed 70dB(A).

The flow of air from the HVAC unit shall be sufficient to dilute escaping gas or vapors, resulting from the failure or rupture of any sample or service line, to less than 20% of LEL around any potential sources of ignition and to maintain house pressure 5mmH2O above the atmospheric pressure to prevent entry of hazardous gas.

Seller shall ensure for each analyzer house the ventilation rate at least 10 volume changes per hour or at least 20m³ of air per installed analyzer per hour, whichever is greater, to dilute any flammable gas or vapor to a non-hazardous level.

Two pressurization fans each rated at 100% of the design duty with automatic changeover shall be provided with each analyzer house. The fan motors shall be suitable for use in Zone1 area. The fan shall be non-sparking type. The ducting to the fan inlet shall be protected from the ingress of rain water or significant blowback by wind, and shall be complete with a wire mesh screen to prevent the entry of birds, vermin or particulate matter. Neither wind speed nor direction shall have any effect on the ventilation.

Analyzer house shall be air conditioned by air handling units. The unit shall comprise of fan section, pre-filter (EU3) direct expansion cooling coil and refrigeration compressor and associated air cooled condenser. This equipment, including any controls, shall be suitable for use in a Zone 1 area.

Air shall enter the analyzer house at ceiling level from ducting via openings with adjustable flow diverters to facilitate a proper direction and flow of air throughout the analyzer house. The ventilation air shall escape from the house through vertical ducts at two opposite corners of the house, via louvers with adjustable openings.

The ducts should be installed on the outside of the short walls and connected to the interior of the analyzer house by openings in these walls which are flushed at floor and ceiling level to allow escape of gases and vapors both heavier and lighter than air.

There shall be separate power supply for the ventilating fans and shall have tripping circuit to trip the motors in case of fire.

Each fan support and casing construction shall be of adequate rigidity to prevent resonance and vibration. The fan bearing support shall be the part of fan casting.

Low flow switch shall be provided with each fan to detect air flow to the house. The switch shall be set to indicate flow failure when flow falls below 60% of design flow. A time delay of 1 min. to be provided to avoid spurious operations due to short term disturbances. Low flow alarm shall initiate visible (lamp on annunciator) and audible alarm and makes change over to the other system.
During start up of the house, both the HVACs shall run for the predefined period.

Reset buttons for both the HVAC units shall be provided on safeguarding panel. This switch shall be used to reset the latched HVAC unit alarm. The alarm latching is required to avoid the changeover to the same HVAC unit until it is attended to.

2.6.1 Vendor shall design, engineer, procure, manufacture, inspect & test at works, shop-paint, pack & forward, transport, supply install, test and commission the HVAC System for Analyser Shelter complete with all auxiliaries required for efficient & satisfactory operation. Vendor shall carry out Performance Guarantee (PG) test at site to prove the Guaranteed Parameters. The specifications for HVAC system shall be as detailed in 2.6.2 for Analyser Shelters located in hazardous area and 2.6.3 for Analyser Shelters located in safe area.

2.6.2 HVAC System for Analyser Shelter Hazardous Area

2.6.2.1 Analyser Shelters shall be air conditioned and pressurized to prevent the entry of flammable gases & vapours and combustible dusts.

2.6.2.2 Air Conditioning and pressurization shall be achieved by providing packaged type HVAC units as per manufacturer’s standard practice.

2.6.2.3 Pressurisation system shall be provided for analyser shelter with 2 nos of HVAC system (one working unit and one standby unit) each of same capacity without any common / sharing components. Fresh air shall be taken from safe area. Fresh air intake arrangement comprising of fresh air blower with drive & back draft dampers, cleanable type filter (95%, 5 micron) and bird screen etc. shall be provided. Relief dampers shall be used to exhaust room air at 5 mm WG over pressure. Shelter internal positive pressure shall be maintained at 2.5 mm WG minimum. Fresh air stack with rain cap shall be of carbon steel, welded in construction of minimum 2 mm thick. Fresh air shall be taken from nearest safe area through fresh air stack in a guy wire style or through horizontal/ vertical duct. The Ducts shall be completely leak proof while passing through hazardous area. Loss of pressurization shall initiate an audio-visual alarm. Manual HVAC selector switch to alternate between the HVAC shall be provided in the shelter. Special anti-corrosive coating shall be provided for coolant tubes to withstand harsh refinery environment."

2.6.2.4 Fresh air make up requirements shall be calculated by the vendor based on the requirements as specified in Clause 8.3 of NFPA 496, (Latest Edition), i.e. where a release of flammable gas or vapour within an enclosure can occur either in normal operation or under abnormal conditions, protection shall be provided by diluting with air to maintain the concentration of flammable gas, vapour, or mixture to less than 25% of its lower flammable limit of any individual flammable gas or vapour entering the enclosure. However minimum 5 air changes shall be provided as per IEC 61285 for ventilation purpose. Inside temperature rise shall be limited to 5°C above ambient, by fresh air from pressurisation system, in case of failure of AC system.

2.6.2.5 Vendor shall confirm that all analysers installed inside Analyser Shelters are suitable for continuous operation in this temperature (Max. ambient +5°C). In case any analyzer being supplied is not suitable for this temperature limit, vendor shall provide high temp pre alarm inside shelter. A separate potential free contact of this alarm shall be provided in alarm J.B. for
connection to control room also. The power to analyzer shall be cut off in case of high temperature.

2.6.2.6 Vendor shall submit heat load calculation for review during post order engineering. Heat load on account of fresh air shall be considered while calculating the capacity of air conditioners.

2.6.2.7 All equipment shall be suitable for operation in their respective area classification. For Analyser shelters located in classified area (Zone - 2, Gr. IINIBIIIC), HVAC unit is required to be explosion-proof in construction. All flameproof equipments manufactured locally (within India), the testing shall be carried out by any of the approved testing houses – CMRI/ERTL etc. The item shall, in addition, bear the valid certification from PECB/CCE and also the manufacturer shall hold a valid BIS license. All equipments manufactured abroad shall be certified by any approving authority like BASEEFA, FM, UL, PTB, LCIE etc. In addition certification by Indian Authorities PECB/ CCE, Nagpur, is mandatory.

2.6.2.8 Chemical Filters shall be provided in the fresh air intake to protect the electronic equipment installed inside the analyzer shelters against corrosive gases like H,S, SO" NOx etc. as per specification clause 2.7.

2.6.3 HVAC System for Analyser Shelter Safe Area

2.6.3.1 Analyser shelters are to be air conditioned and pressurised to prevent the entry of dust.

2.6.3.2 Air Conditioning and pressurization shall be achieved by providing packaged type HVAC units as per manufacturer's standard practice.

2.6.3.3 Pressurisation system shall be provided for analyser shelter with 2 nos of HVAC system (one working unit and one standby unit) each of same capacity without any common / sharing components. Fresh air intake arrangement comprising of fresh air blower with drive & back draft dampers, cleanable type filters (95%, 5 micron) and bird screen etc shall be provided. Minimum 5 air changes shall be provided as per IEC 61285 for ventilation purpose. Inside temperature rise shall be limited to 5° C above ambient, by fresh air from pressurization system, in case of failure of AC system. Relief dampers shall be used to exhaust room air at 5 mm WG over pressure. Shelter internal positive pressure shall be maintained at 2.5 mm WG minimum. Loss of pressurisation shall initiate an audio-visual alarm. Manual HVAC selector switch to alternate between the HVAC shall be provided in the shelter. Special anti-corrosive coating shall be provided for coolant tubes to withstand harsh refinery environment.

2.6.3.4 Vendor shall confirm that all analysers installed inside Analyser Shelters are suitable for continuous operation in this temperature (Max. ambient +5°C). In case any analyzer being supplied is not suitable for this temperature limit, vendor shall provide high temp pre alarm inside shelter. A separate potential free contact of this alarm shall be provided in alarm J.B. for connection to control room also.

The power to analyzer shall be cut off in case of high temperature.

2.6.3.5 Vendor shall submit heat load calculation for review during post order engineering. Heat load on account of fresh air shall be considered.
2.6.3.6 Chemical Filters shall be provided in the fresh air intake to protect the electronic equipment installed inside the analyser shelters against corrosive gases like H2S, S02, NOX etc. as per specification clause 2.7.

2.6.3.7 Vendor shall submit heat load calculation for review during post order engineering. Heat load on account of fresh air shall be considered while calculating the capacity of air conditioners.

2.6.4 **Inside Conditions to be maintained**

Following inside conditions are to be maintained and guaranteed by vendor throughout the year:
- Dry bulb temperature: 26°C ± 1°C
- Relative humidity: 35% to 70%

2.6.5 **Outdoor Design Conditions**

Outdoor design conditions, as mentioned elsewhere, shall be considered for heat load calculation.

2.6.6 **Spares**

Spares for commissioning and start up as required shall be provided by vendor without any additional time & cost implication.

2.7 Chemical Filters

2.7.1 The design, selection, manufacture and supply of chemical air filters for the duty specified shall be in vendor’s scope.

2.7.2 Chemical air filters are required to be installed in fresh air circuit.

2.7.3 **Selection Data for Chemical Filters**

The following conditions shall be considered as a minimum for outside ambient air:

<table>
<thead>
<tr>
<th>GAS</th>
<th>OUTSIDE (g/m³)</th>
<th>INSIDE (PPM by Vol.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yearly Average</td>
<td>Max. (8 hr. average)</td>
</tr>
<tr>
<td>S O₂ / SO₃</td>
<td>100</td>
<td>13000</td>
</tr>
<tr>
<td>NOₓ</td>
<td>100</td>
<td>9500</td>
</tr>
<tr>
<td>H₂S</td>
<td>TRACES</td>
<td>13900</td>
</tr>
<tr>
<td>* Cl₂</td>
<td>TRACES</td>
<td>2900</td>
</tr>
<tr>
<td>* NH₃</td>
<td>TRACES</td>
<td>TRACES</td>
</tr>
<tr>
<td>SPM</td>
<td>400</td>
<td>15000</td>
</tr>
<tr>
<td>RSPM</td>
<td>250</td>
<td>-</td>
</tr>
</tbody>
</table>

* Normally not associated with Refinery emission.
2.7.4 Technical Specifications for Chemical Filters

2.7.4.1 Chemical air filter unit shall be selected to provide inside conditions as given above considering the outside ambient concentrations given under Max. (8 hrs. average) column.

2.7.4.2 Chemical air filter shall be selected for the chemical media life of minimum 2 years. The outside gas concentration given above shall be considered while evaluating the life. Chemical Filter supplier to furnish the calculations and nomographs etc. in support of the chemical media life, at post order stage.

2.7.4.3 Chemical air filter unit shall be skid-mounted cubicle for horizontal installation.

2.7.4.4 Three stage chemical filter shall be provided – one/two modules containing Puracarb or equivalent media and other metal modules containing chemisorbant or equivalent media.

2.7.4.5 Filter packs suitable for removal of specified gases shall be housed in an adequately rigid & reinforced sheet metal enclosure, with flanged inlet & outlet connections, inspection cover/manhole.

2.7.4.6 The pre-filters at inlet & fine filters at outlet shall be capable of removing dust particles of 10 microns with 90% efficiency & of 1+ microns with minimum 90% efficiency respectively.

2.7.4.7 Unit shall be suitable for outdoor installation & continuous operation. It shall be painted as per painting specifications of the Bidding document.

2.7.4.8 It should have adequate provision for easy removal & servicing of filter packs.

2.7.4.9 Unit shall be provided with indication of differential pressure across the filters.

2.8 Power Supply

2.8.1 Unless otherwise specified, the following power supplies shall be provided for each shelter at one point near the shelter by owner. Further distribution step down etc. as per requirement shall be done by the vendor:

i) 415V, 50Hz, 3 phase with neutral for the HVAC system.

ii) 110VAC 50Hz Single phase for analyser, alarm system, horn and other related accessories.

230V 50Hz Single phase for lighting (internal and external) system of the shelter and heat tracing shall be developed by vendor.

2.8.2 The supply voltage fluctuation of ±10% and supply frequency fluctuation of±3Hz from the specified value, shall not affect the system performance.

2.8.3 The size and number of incomers shall depend on load and distance and shall be finalized during detail engineering. Vendor shall provide necessary terminal sizes and suitable cable glands.

2.8.4 Main switches for all three-power supplies shall be mounted outside the analyser shelter,
which shall be weather proof to IP66 and explosion proof suitable for the specified hazardous area classification. The power supply cables will be terminated after the main switches inside the shelter in different junction boxes with terminals and switch fuse unit for power distribution to the relevant equipments/items. Individual switches shall be provided for each instrument for independent de-energisation of the items. ‘Power Supply on’ indication shall be provided on the main power supply line to each analyser on PDB.

2.8.5 Two power sockets of IIOV 50Hz and nov 50Hz supply for electrical tools or test equipments shall be provided at two opposite corners of each shelter.

2.9 Other Utilities

Owner shall provide following utilities at one point near each shelter. Further distribution shall be done by vendor as per the requirement.

2.9.1 Steam

   a) Pressure:  2.5 - 5.5 kg/cm²
   b) Temperature:  Saturated

   c) Line size connection:  1" NB NPT (M) with valve.

2.9.2 Instrument Air

   a) Pressure:  4.0– 6.0 kg/cm²
   b) Dew Point:  - 40°C at atmospheric pressure

   c) Line size connection:  1.0" NB NPT (M) with valve

2.9.3 Cooling water

   a) Pressure:  3.5 - 5.0 kg/cm²
   b) Temperature:  33°C

   c) Connection size:  1.0" NBNPT (M) with valve

2.9.4 Nitrogen

   a) Temperature:  Ambient
   b) Pressure:  5 - 8 kg/cm²

   c) Connection size:  1.0" NBNPT (M) with valve
Vendor shall furnish the list of utilities required with expected consumption.

2.10 Lighting

2.10.1 Power supply for lighting inside and outside the shelter shall be 230 V 50 Hz.

2.10.2 Internal lighting shall be provided by fluorescent tube lamps to provide in illumination of 300-400 lux at all places on the floor.

2.10.3 External lighting shall be under overhangs to provide illumination sufficient for maintenance / repair work.

2.10.4 Lighting fixtures inside and outside the shelter shall be suitable for the hazardous area classification specified.

2.10.5 Lighting switch shall be provided outside the shelter near to the main door.

2.11 Terminal Housing

2.11.1 The terminal housing shall be suitable for the area classification indicated in the purchaser's data sheets. Unless otherwise specified, the enclosure shall comply with the following requirements as a minimum:

Weather proof housing: IP-65 as per IEC-60529/IS-13947

Flameproof housing: Flameproof/Explosion proof i.e., Ex (d) as per IEC 60079 / IS2148 for explosion proof construction

Flameproof housing shall also be made weather proof and shall be provided with metallic enclosure.

2.11.2 All cables shall terminate on the terminal blocks in all vendor-supplied equipments, Separate terminal blocks shall be provided for power and signal cables. Unless otherwise specified, terminals shall be suitable for terminating following conductor sizes, as a minimum:

- Signal cables : 1.5 / 2.5 sq. mm
- Power cables : 6 sq. mm

Separate terminal box shall be provided in case instrument terminals available as standard are not suitable to accommodate the specified conductor sizes.

2.12 Tubing / Piping / Wiring

Tubing and piping runs shall be installed such that they will not interfere in the maintenance or removal of any analyzer or equipment in the house or shelter nor encroach on space allotted for future instruments. All valves and instruments shall be readily accessible.

Traps shall be provided and installed by Seller outside the house or shelter for all steam traced inlet
sample lines and steam users. Each steam user shall have its own trap.

All users of instrument air shall have block valves at the take off point. All sample inlet and outlet points shall have isolation valve.

All piping and tubing shall be adequately supported. All tubing shall be protected by running it in trays or channels.

All tubing shall be annealed SS-316, 1/2 inch OD by 0.049” wall thickness or 1/4 inch OD by 0.035 wall thickness as appropriate. Fittings shall be Flare less SS-316.

Other materials for tubing and/or fittings may be considered where required by process conditions.

2.12.1 All safety valve outlets shall be terminated in a common header of 2” NB schedule 80S Stainless Steel 304 pipe and single outlet shall be provided out side the shelter with one non return valve and lock open type 1” ball valve. Similarly all vents to atmosphere shall be terminated in a similar 2” NB Schedule 80S Stainless Steel 304 pipe and single outlet shall be provided. If commom header is not there then with non-return valve and Lock open type 1” ball valve.

2.12.2 All atmospheric gas out line shall be equipped with protection from climatic condition.

2.12.3 All tubing work shall be done by using 1/2.” OD or 118"OD SS tube aod Swagelok/ Parker/ Hamlet flare less, double compression type fittings.

2.12.4 All wiring/ tubing and all other erection work shall be done in accordance to API RP 551-5

2.12.5 All cable entries/outlets in the junction boxes/ distribution boxes etc and to the analyzer shall be provided with double compression type certified flameproof cables glands suitable for the indicated hazardous area. The material of the same shall be Nickel-plated brass.

2.12.6 All cabling/wiring works inside the shelter shall be in accordance with the international Standard / industry practice for similar application. However the cables shall be armoured as a minimum.

2.12.7 Dimensions and layout of each shelter shall be provided by contractor for Owner / PMC review before taking up for fabrication.

2.13 **Hook up of Analyser Shelter**

2.13.1 End Connections shall be provided for all interconnections (fast loop return, sample return, utilities, flare, vent, drain etc.) as specified in purchaser's data sheet for their hook up.

2.13.2 In case end connection for hook up of vendor's standard supply is different than that specified in the purchaser's data sheet, vendor should include the required hook up material in their scope of supply.

2.13.3 Unless otherwise specified, end connection details shall be as below:
a) Threaded end connections shall be NPT as per ANSI/ASME B 1. 20.1.

b) Flanged end connections shall be as per ANSI/ASME B 16.5

c) Grooves of ring type joint flanges shall be octagonal as per ANSI 16.20.

d) Flange face finish shall be as per clauses 6.4.4.1, 6.4.4.2 and 6.4.4.3 of ANSI/ASME B 16.5. The face finish as specified in the data sheets, shall be as follows:

<table>
<thead>
<tr>
<th>AARH</th>
<th>125 to 200 AARH</th>
</tr>
</thead>
<tbody>
<tr>
<td>63 AARH</td>
<td>32 to 63 AARH</td>
</tr>
</tbody>
</table>

2.14 Foundation:

2.14.1 The analyzer shelter shall be installed on 200 mm high concrete pedestal provided on paved area in the plant by owner. The pedestal shall be extending 1 meter all around the footprint of analyzer shelter.

2.14.2 Analyser shelter shall be supplied with base channel of min. ISO mm height which will be bolted to the pedestal.

2.14.3 Vendor shall arrange all equipments outside the shelter including HVAC in such a manner that they are accommodated on the pedestal.

2.14.4 All civil works necessary to install the shelter on pedestal and any residual civil work to provide additional foundation for any accessory shall be in Vendor scope.

2.15 Painting

2.15.1 Non SS parts of the analyzer shelter shall be treated and painted as follows:

a) All surfaces including structures shall be sand blasted and grinded smooth and free of scale, rust etc.

b) Chemical treatment shall be done to remove rust, oil, entrapped impurities and other foreign materials.

c) Exterior and inside colour of shelter shall be finalised during detailed engineering.

3.0 NAMEPLATE

3.1 Each analyser shelter shall have a stainless steel nameplate attached firmly to it at a visible place near the main and Emergency doors, furnishing the following information:

a) Tag number as per purchaser's data sheet.

b) Manufacturer's serial number (If any).

c) Manufacturer's name/trade mark.
d) Area classification in which the shelter can be used.

e) Size of shelter.

Seller shall fit a nameplate with the analyzer house number (e.g. AH-01) to both doors on each analyzer house.

Seller shall also fit an appropriate warning boards like following:
• Analyser house protected by artificial ventilation
• Warning - doors shall be kept closed
• Warning - risk of H2S
• Warning - flammable material shall only be introduced into the analyser house if specifically permitted and recorded.

Seller shall clearly identify all services with name plates, (for steam this shall also indicate maximum pressure and temperature), at entries to analyzers both internally and externally and entries to sample conditioning systems.

Seller shall clearly identify all sample flow and return lines, carrier gas and calibration gases with name plates, at entries to analyzers both internally and externally and entries to sample conditioning systems.

All nameplates, labels and signs shall be in dual language, Hindi and English. In addition any signs for extreme caution, such as the risk of Hydrogen Sulphide shall also be in Bangla.

All parts inside and outside of the analyzer house, inside sample conditioning system, HVAC, safe guarding PLC shall have a nameplate indicating the label of that part for identification. The parts in Sample conditioning system shall also be printed with their set point or normal values in the second line of the label.

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at the vendor's works.

4.2 Vendor shall submit the following test certificates and test reports for purchaser's review:

a) Material test certificate as per clause 3.1B of EN 10204 for flanges, fittings and sheet steel.

b) Certificate of radiography/ X-ray for header welded joints. Dye penetration test certificate shall be provided for joints where radiography/ X-ray is not possible.

c) Dimensional verification certificate as per clause 4.3 of this specification.

d) Hydrostatic testing of all headers.

e) Leakage and continuity testing.

f) Power Distribution and wiring check

g) Functional check for HVAC
h) Type test certificates

Seller shall carry out a complete inspection of all analyzer houses, to ensure all analyzers, analyzer sample systems, pipe and tube work, utilities, drain and vent systems, heating and ventilating system plus all analyzers which are field mounted are in manufacturer’s perfect working order. The analyzer house Seller shall permit inspection by the client at any time during the actual construction of any part or parts of the project.

Seller shall make following facilities available for test:
- Sufficient qualified labour to carry out the test.
- Air or nitrogen at required pressure for the full duration of the test.
- Air bubbler, maximum working pressure 10kg/cm2(g).
- A gas/air leak detector
- Measuring equipment for supplies and outputs (multi-meter).
- Special measuring tools/equipment for components installed.
- Power supply units as applicable.
- Three copies of the as built drawings.
- Test and calibration gas/liquid samples for each analyzer.

Inspection and full functional testing shall then be carried out at Seller’s premises of all analyzer houses and systems and all field mounted analyzers, with the analyzer house Seller’s responsible analyzer specialist and the Client. This will include a full calibration test of each analyzer.

The analyzer house seller shall then ensure safe transportation of each analyzer house, complete with analyzers, sample systems and contents, plus all field mounted analyzers and their equipment, to the site, where they shall be installed by client under Seller’s supervision.

All field equipments, including field mounted analyzers sample systems and as sociated analytical equipment that is not mounted in each house shall be installed by Client under Seller’s supervision.

Analyzer house Seller’s responsible analyzer specialist shall then carry out a complete inspection to ensure all analyzers, their systems and all utilities are in manufacturer’s perfect working order before each analyzer system and all utilities are commissioned by the analyzer house specialist. This will include a full calibration test of each analyzer.

The sample transport and return lines shall be disconnected from the preconditioning panel and sample conditioning cabinet and then flushed out with demineralised water. The system shall then be dried using clean air or nitrogen.

Analyzer house Seller shall carry out pressure test and inspect the sample transport and sample conditioning systems before the system is offered for inspection by the client.

During the leak test, all inlets and outlets shall be capped off, with the exception of those which are provided with a valve. The isolating valve shall be closed for these connections. The analyzer shall not be included in the leak test and shall be disconnected at the inlet and outlet connection. All other valves and reducers shall be fully opened. The maximum pressure applied shall not exceed 10 kg/cm2(g). Each system shall be pressurized for at least five minutes while the bubbler is carefully observed.

Systems or parts with a design pressure up to 9k g/cm2(g) shall be isolated from the system having higher design pressure and shall be opened to atmosphere during the pressure test. Systems or parts of
systems with a design pressure higher than 9kg/cm²(g) shall be pressurized at 1.5 times the design pressure via a tight shut-off valve and a high-quality pressure gauge.

4.3 Dimensional Verification

4.3.1 End connection dimensional details shall be verified for all instruments and their accessories in accordance with approved drawings. In any case, the variation shall not exceed ±2.0mm.

4.4 Hydrostatic Testing

All headers shall undergo hydrostatic testing at 1.5 times the header design pressure with water at ambient temperature. These shall not be any visible leakage during the testing.

4.5 Continuity Testing

a) All power cables shall be megger tested at minimum 600V. The insulation shall be as per IS-1554 Part I.

b) All signal cables / wires shall be checked for continuity, termination and identification using multimeter.

4.6 Leakage Testing

All tubing and piping shall undergo leakage testing when pressurised with nitrogen at 100 psig. No bubbles shall appear when testing with soap solution.

4.7 Witness Inspection

4.7.1 Vendor shall offer all analyser shelters for pre-dispatch inspection at their works. Following tests/checks shall be carried out, as a minimum.

a) Physical dimensional verification and workmanship as per clause 4.3 of this specification.

b) Leakage testing of tubes and headers with nitrogen as per clause 4.5 and 4.6 of this specification.

c) Power distribution and wiring scheme check

d) Insulation resistance work

e) Functional check of HVAC

f) Review of all certificates and test reports as indicated in clause 4.2 of this

4.7.2 In the event the witness inspection is not carried out by purchaser, the tests shall anyway be completed by the vendor and documents for the same shall be submitted to purchaser for scrutiny.
5.0 UTILİTY SERVICES

Seller shall provide a suitable distribution system as required. All service lines must have a minimum distance of 25mm clear between neighboring flanges. Steam and condensate lines shall have an allowance for insulation.

Seller shall provide a suitable distribution system for carrier gas, calibration gas, instrument air, etc as required for each analyzer. A means shall be provided to initiate an alarm on low pressure/volume in the header or cylinders.

All piping and tubing from headers, analyzers, cabinet drains, vents, steam users and steam tracing inside the shelter shall be brought to the outside so that, at the jobsite, all connections can be made outside the shelters.
6.0 SAFEGUARDING SYSTEM

Each analyzer house shall be protected by a safeguarding system against hazardous situations. Seller shall supply safe guarding PLC, fire & gas detector, alarm initiating devices, annunciatior etc. fully wired with respective junction box or PLC.

Seller shall develop the “Cause & Effect Diagram”, “Functional Logic Diagram” and Input-output list for safe guarding PLC and submit the same to the client for approval. After client’s approval Seller shall develop the logic and load into the PLC. The logic and Input-output configuration shall be uniform for the all analyzer houses supplied by Seller.

The proposed interconnectivity among the systems like Safe guarding PLC, Annunciatior, GC, AMS system, plant FGS, plant DCS, AMS PLC, etc. shall be provided. The seller shall prepare the final interconnection diagram during detail engineering stage and submit to the client for review and/or approval.

**AIR INTAKE**
The presence of flammable or toxic gas at the point of fresh air intake of the ventilation system shall be monitored by Gas detectors. The Gas detectors shall be fitted in such a way that the prevailing flow profiles and air speed inside the ducting do not adversely affect either representative sampling or the accuracy of detection. The detector should easily accessible for maintenance.

**INSIDE ANALYZER HOUSE**
Flammable gas detectors shall be installed in the direct vicinity of the controlled outlet opening of the ventilation system inside the house. Toxic gas detectors shall be located at positions where leakage into the analyzer house is most likely to occur in case of failure or mal-operation. Hydrogen gas detectors shall be installed if Hydrogen is used as carrier gas for Gas Chromatographs. Optical Smoke detector shall be installed inside the house to detect smoke/fire. Oxygen detector shall be installed inside house to alarm on oxygen deficiency. Flashing lights – RED & GREEN shall be installed inside the house. Flesching RED light shall indicate “unsafe” condition inside the house. Steady GREEN light shall indicated “healthy (safe)” condition of the house. The lights shall be installed in such a way that the person can see through the glass window mounted on the.

**OUTSIDE ANALYZER HOUSE**
A Manual Call Point (MCP) shall be provided outside the analyzer house near main entrance. Actuation of MCP shall trip the analyzer house. RED & GREEN lights shall be over the roof of the house. RED light shall indicate trip condition of the house and GREEN light shall indicate healthy condition of house. These lights shall server the purpose of indication of house condition from remote. Air horn shall be installed outside the analyzer house. The horn shall blow whenever any alarm or trip is initiated by any of the device inside or outside the house. The horn shall have minimum sound amplitude of 100dBA.

**ANNUNCIATOR**
Indication lamps for each gas or fire detection, HVAC run/fault, house purging, house pressure, power available, etc. shall be provided on annunciator panel outside the analyzer house near main entrance. Alarm acknowledge, reset and lamp test push buttons shall be provided on the annunciator. All signals annunciator shall be wired to Safe guarding PLC. The annunciator enclosure shall be suitably certified for the area classification.
SAFE GAURDING PLC
Safe guarding PLC shall be supplied by analyzer house seller and shall be installed in a purged enclosure inside the analyzer house along with all necessary wiring, power supply, barriers, relay, MCBs, etc.

The safe guarding system shall be independent of the main process ESD system.

The Fire & Gas System(supplied by other) of main plant will receive inputs from the fire and gas detectors of analyzer house and send output to safe guarding PLC for annunciation, beacon, alarm or trip.

In the event of an analyzer house power being isolated by the safe guarding system the power shall be restarted only by pressing the reset switch located outside the analyzer house.

• Safe guarding system for each analyzer house shall perform following actions, in the event of ventilation failure, loss of over-pressure, flammable or toxic gas detection, O2 deficiency, etc.
  • Initiate an appropriate audio and visual alarm
  • Isolate power to the wall sockets
  • Isolate power to analyzers not certified for use in Zone1 hazardous area, isolate data highway for any analyzers connected to the Analyzer Management System and isolate any non- Intrinsically safe signals.
  • In the event of fire detection or actuation of MCP outside the house, the safe guarding system shall carry out the above actions and the following:
    • Isolate power to the analyzer house
    • Isolate all sources of flammable material – sample, carrier gas, etc.
    • Isolate the ventilation fans
    • Close the fire damper at air inlet stack

Seller shall ensure that all equipments to be isolated above with the exception of the ventilation fans, cannot be re-energized until the ventilation system is operating, the house is repressured and at least five fresh air changes have taken place. All internal panel wiring shall be within plastic trunking. There shall be separate trunking for signal types including IS and Non-IS and for Electrical supplies, with sufficient segregation to eliminate interference. The trunking shall be sized with at least 40% spare capacity.

Between two rows of terminal there shall be plastic trunk (75mm x 75mm) minimum to receive field wiring for the panel.

7.0 ELECTRICAL UTILITIES

POWER
Following power to the analyzer house shall be supplied by client at single point on analyzer house:

220VAC ± 3%, 50 Hz ± 0.5Hz UPS power for Analyzers and Safe guarding PLC
240VAC, 50Hz Non-UPS power for lighting, maintenance socket, heater in Sample conditioning system, Sample pump, etc.

415VAC, 50Hz, 3-Phase for HVAC motors, sample pump motors, etc. Further distribution to individual device or equipment shall be supplied pre-wired by Seller.

A manual power disconnect switch for each voltage feeder with padlock option shall be installed on the outside wall of each analyzer house / shelter.
All power distribution boards mounted on the analyzer wall shall be suitable for use in Zone1 area and classified EEexd IIC T6, these shall be supplied by seller.

Seller shall calculate the expected load, for each supply voltage, with a 30% allowance for future expansion; these calculations shall be supplied to the client. All distribution boards shall have 30% spare capacity for future expansion.

The protection of power circuits shall be provided in both live and neutral lines and shall be either switches/fuses or MCBs. It shall be possible to “lock off” an isolated circuit. Cables entering distribution boards shall be terminated at suitably sized and rated terminals.

Bus bars and fuse blocks / switch blocks / MCBs shall be used for power distribution and shall be installed in such a way that any equipment can be disconnected from or connected to the system without interrupting power supplies to other equipments. Provision shall be made to provide a minimum of 30% spare for future requirement. Power supply wiring shall not be jumped from one instrument / device to the other.

Seller shall provide wall sockets installed along the internal walls. These shall be provided with adequate protection for a Zone 1 area. The supply to wall sockets shall be protected in both live and neutral lines by residual current breakers and either switches/fuses or MCBs. In the event of ventilation failure or 20% LEL gas detected power to the sockets and equipment not certified for Zone 1 IIC T6 use shall be isolated. The sockets shall be provided for both 240VAC UPS and 240VAC, utility supply.

Power to all electrical equipments inside the house which are not suitably protected for a Zone 1 hazardous area shall be isolated by Safe guarding system if a ventilation failure occurs.

CABLE

Electrical Power and Instrumentation Signal/Communication cables shall enter and leave analyzer house via separate cable transits mounted in the analyzer house walls.

Cable glands shall be used on all junction boxes or equipment entries. Glands shall be suitable for cable types and hazardous area classification.

Cable connections from chromatograph analyzers to its programmer or its computer shall not be cut. The cable shall be extended through the analyzer shelter intact, coiled, and marked by the Supplier so that connections can be made to the proper remote control section or computer.

All internal cabling shall be run on perforated galvanized cable tray. Adequate separation of signals level and voltage shall be maintained to ensure signal integrity.

The minimum size of power and lighting circuit cables shall be 2.5mm2 and also for all fire and gas detector cable size shall be 2.5mm2 and other instrument signal wiring shall be 1.0mm2 minimum.

Physical segregation of wiring for each signal type and power supply shall be maintained. Single core cables within panels shall be color coded for different signal types and power. Seller shall supply details of his color coding system.
JUNCTION BOX

Seller shall provide NEMA 4X (IP65) terminal boxes on the outside of each house and shall be certified for Zone1 hazardous area. Separate junction boxes shall be provided for Analog signals, Digital Signals, Fire & Gas signals and Communication signals. Seller shall provide leads inside the shelter from these junction boxes to each analyzer, fire & gas detector or safe guarding PLC.

Further cabling from these junction boxes to Plant DCS, ESD or Fire & Gas detection system shall be carried out by Client.

The multi-core cables shall enter the junction box via bottom gland plate and all other cables shall enter via side gland plates. There shall be no top entries.

All terminal blocks shall be of the screw type, with barriers and marking strips. All wires shall have cross ferrules at each end by means of a small plastic sleeve (permanently stamped). Each terminal block shall have a minimum of 20 percent spares.

Wiring between terminals shall be continuous runs and shall not be spliced. With the exception of solid jumpers, not more than two wires shall be connected to one terminal.

The wiring shall be segregated as AC wiring, intrinsically safe DC wiring, and non-intrinsically safe DC wiring, communication wiring and power wiring.

LIGHTING

Seller shall supply suitable and adequate lighting for each house, both internally and externally, to supply illumination level minimum of 400 Lux. All fittings shall be suitable for use in a Zone 1 area, certified EEExd IIC.

Failure of any one light fitting shall not mean that any part of the house shall fall below an acceptable illumination level. Seller shall provide minimum one light with battery backup for one hour with each house.

Both internal and external lights shall be controlled from switches placed externally at both entrance doors. Switches shall be certified for Zone 1 use.

EARTHING

Provision shall be made for three (3) independent earth connections to the safe guarding panel - plant earth, instrument earth and intrinsically safe (IS) earth.

The Plant earth - All removable doors and covers, gland plates, instrument cases, etc, shall be connected to the plant earth. Earth studs, size M10, shall be provided inside the panel, located at the bottom of the panel. All protective earths shall be connected to these studs.

Instrument Earth - an electrically isolated copper instrument earthing busbar shall be located at the bottom of the panel. Both ends shall have an earthing lug capable of accepting a 16mm² copper earth wire. The busbar shall be positioned below terminal blocks to allow easy access for the connection of earth wires. Cable screens and electronic loops requiring earthing shall be directly connected to the earth busbar and loop-connection of screens shall not be allowed. A minimum of 30% spare connecting points shall be provided.
Intrinsically Safe Earth - An electrically isolated copper IS instrument earth busbar shall be located at the side of the panel. Both ends shall have an earthing lug capable of accepting a 16mm2 copper earth wire. This earth bar shall be used for intrinsically safe circuits. A minimum of 30% spare connecting points shall be provided.

Apart from the above earthing, Seller shall supply a non-insulated “plant” earth bar within the analyzer house above floor level. All metal enclosures for electrical equipment, including analyzers and auxiliary equipment shall be bonded to this earth bar. The minimum size of earth conductor shall be 6m2. Provision shall be made for site connection of two 70mm2 earth conductors to the earth bar. Earth continuity shall be ensured throughout the analyzer houses including all doors and framework.

8.0 DOCUMENTATION

Seller shall submit to the client following design and engineering documents as minimum:
• Schedule of Seller documents and drawing
• General arrangement in detail with all assemblies or items within the assembly including overall dimensions and location, gross weight, transporting support, lifting arrangement, earthing details, face to face dimensions, etc.
• Exploded/cross sectional View – Drawing indicating assembly details, description of component and material description and part no. against which the spares can be ordered.
• Analyzer house and panel layout drawings - clearly showing overall size, cut out details, list of instruments showing label engravings, paint finish and color, frame dimensions, etc.
• Schematic Drawing – Drawing shall indicate the electrical arrangement of all components shown in a de-energized state.
• Interconnection diagram - Block diagrams will show interconnecting cables among Instruments, analyzers, electrical equipment, junction box, safe guarding plc, annunciator, sample conditioning system, etc. indicating cables not in Seller’s scope of supply.
• Internal wiring diagram for all instrument and electrical termination details including Junction box, safe guarding plc, analyzers, etc. terminations.
• Instruments layout drawing – indicating location of each instrument with tag no. with elevation, tubing or cable layout, instrument air line layout, etc.
• Functional logic diagram – for sequence of operation and interlock logic of safe guarding plc.
• Instrumentation data sheet for each instrument installed in the house including Fire and gas detectors.
• Instrument & Electrical Cable schedule – which will list all cables with type, size, length and location.
• Installation, commissioning, operation and maintenance manual for all equipments installed in the house including, HVAC, PLC, Annunciator, Analyzers, fire and gas detectors, instrumentation items, electrical items, etc.
• Instrument loop diagrams – indicating location and termination details of each instrument with safe guarding plc or analyzer
• Sample hook up drawing – from sample take off to sample conditioning system to analyzer and return to sample line. This will indicate vent and drain lines.
• Detailed bill of materials for all items / parts with their make, model and ordering information.
• Commissioning spare list

9.0 PACKING AND SHIPPING
Each instrument and all moving parts shall be securely packed and properly packaged, boxed, or crated to prevent damage to instruments and parts while handling, during shipment, delivery, and warehousing.
All glass shall be covered with cardboard or wooden protectors and the complete instrument wrapped or packed in a container of suitable design to withstand normal shipping, handling, and indoor storage.

All openings (including tubing and pipefitting) shall be covered, plugged, or capped to prevent entrance of foreign materials and contaminants during transit and storage.

All framed openings of the shelter shall be weather sealed for shipping.

Field mounted analyzers, auxiliary equipment or other heavy items shall be provided with additional bracing to prevent them breaking loose during shipment. All supports which will be in contact with equipment in the analyzer houses shall be suitably protected.

10.0 SERVICE AND SUPPORT
Seller shall accept full system responsibility for all supplied hardware, operating and application software, and provide the necessary training, and site support for the construction, staging, testing, installation and pre-commissioning phases per this specification until successful hand over to the contractor.

• Seller’s responsibility shall include, but is not limited to, the following items:
  • System engineering support
  • System hardware and operating system software
  • Software for interfacing all foreign devices
  • System documentation
  • Recommended spare parts
  • Factory acceptance testing
  • Packing and shipping per the accompanying requisition
  • Warranty

• Failure of this Specification, Attachments, and/or drawings to state or show materials essential to make the equipment specified complete and operable shall not relieve Seller from the responsibilities for furnishing such materials.

The Client’s review of Seller’s drawings does not relieve Seller from the responsibility of furnishing equipment that will function as intended by this Specification.

Seller must take full responsibility for all supplied equipment and adhere to the requirements of this specification.

11.0 SPARES
Seller shall submit full bill of material including all items with respective manufactures part No. Commissioning spares shall be in seller’s scope of supply.

Bill of Material shall include following
• Analysers (Chromatograph Spares)
• Sample Conditioning System Spares
• Safe Guarding PLC & it’s spares
• JB spare Details
• Fire & gas Detector spares
• Instrumentation items installed inside/outside Analyzer House.
• Electrical Spares including HVAC motors, pumps, tube lights, MCBs, emergency light, etc.

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• Mechanical Spares Details
• Calibration or carrier Gas cylinder details
All above spares details will include complete ordering information for future procurement.

12.0 SHIPPING

All threaded and flanged openings shall be suitably covered to prevent entry of foreign material.

Glass windows shall be covered with thermo-coal sheet of appropriate thickness to avoid damage during transport.

Shipping breaks shall be provided in all equipment, which are supplied in installed condition inside the analyser shelter. Equipment, which is likely to damage during shipment, shall be packed separately for shipment.
REQUIREMENTS FOR ANALYSER SYSTEM

FOR

ANALYSER SHELTER
ANALYSER SYSTEM SPECIFICATIONS

1. GENERAL

1.1 This specification defines the minimum requirements of Analyser System / systems designed for reliable and effective analysis of various process streams.

1.2 All analysers along with their associated equipments shall be installed by the contractor inside the analyser shelters.

1.3 All analyser shelters shall be ventilated, pressurized and air-conditioned. However, all analysers and other associated equipments shall be so designed and selected that these will continue to operate even in case of ventilation / pressurization failure.

1.4 Contractor shall provide all installation material including consumables to install the analysers, sample conditioning systems, sample transfer lines, vent lines and all other accessories. All instruments shall be completely accessible to permit adjustments, calibration and maintenance.

1.5 The components to be furnished for each sample system will depend upon the sample stream conditions. The contractor shall select and provide all the necessary components for each of these systems accordingly.

2. SAMPLING SYSTEM

2.1 The sampling system shall consist of necessary components, including sample probes, sample filters, pressure reducers, safety relief valves, pressure and temperature gauges, moisture separators, flow regulators, flowmeters, isolation valves etc. necessary to prepare the sample for proper analysis.

2.2 All components shall be sized and coupled so as to keep the sample volume to a minimum.

2.3 Calibration zero and span gas connections shall be provided for each analyser.

2.4 The sampling system shall have various sub-assemblies as required. The minimum requirements of each sub-assembly shall be as given below.

2.5 Sample Probe Assembly

a. Sampling probe shall be designed to extract true representative sample from the process line. The design shall prevent particulates from entering into the sample system.
2.6 **Sample Stream Pressure reducing stations:**

a. Contractor shall design and provide sample stream pressure reducing station to minimize sample transfer time maintaining the integrity of the sample. Sample stream pressure reducing stations shall consist of pressure regulators, relief valves, pressure gauges, temperature gauges etc as required.

b. These stations will be located at the sample process connection to minimize transport time lag from the sample point to the analyser.

2.7 **Sample Transfer Line**

a. The sample transfer lines shall transport the fluid sample from the sample stream pressure reducing stations to sample conditioning system located at the analyser house/shelter.

b. Contractor shall provide heat tracing for sample line wherever necessary, in order to maintain the sample integrity.

c. The routing of sample transfer lines shall be done in such a way that the total length between the sampling point and the analyser sample conditioning system is minimum. Short radius bends shall be avoided to avoid excessive pressure drop.

2.8 **Sample Conditioning System:**

a. Sample conditioning system shall be provided by the contractor at the analyser shelter.

b. Multi stream analyser system shall have a separate sample handling subassembly for each stream.

c. Sample conditioning system shall include, but not limited to, moisture separators, filters, rotameters, pressure gauges, flow switches, solenoid valves etc. as necessary for proper analysis of each sample stream. Isolating valves shall be provided as required.

d. Stream selecting valves shall be located as close as possible to the analyser to minimize connecting tubing-length and to minimize the possibility of cross contamination of samples.
e. Stream selecting valves shall be double block and bleed and shall fail closed so as to block the sample from the analyser on loss of motive power.

f. Block valves shall be provided on all process sample lines.

g. Rotameters for measuring all sample flows shall be included.

h. Special precautions may be necessary where catalyst fines and coaling material, and other difficult stream conditions are present.

i. Wherever it is necessary to maintain the handling system at elevated temperature to properly condition the sample, it shall be enclosed in a thermostatically controlled heated enclosure. Enclosure heating shall be with steam heater unless specified otherwise. Sample stream flow adjustments and analyser shutoff valves shall be operable from the front of the enclosure without opening the enclosure door. Sample stream flow, pressure and temperature indication shall be visible from the front of the enclosure.

j. Sample tubing between the sample conditioning system and the analyser shall be kept as short as possible.

2.9 Sample Stream Bypass/ Fastloop:

a. Sample stream bypass/fastloop shall be provided for the sample streams to meet the required sample transport time.

b. Flowmeters shall be provided by contractor for sample bypass/fastloop flow.

space, within or otherwise hazardous area, in which under normal operating conditions a non-hazardous atmosphere exists.

4.3 The interior temperature shall be maintained at 26°C ± 2°C maintained. Contractor shall provide necessary air conditioning, heating, pressurization and ventilation.

4.4 Contractor shall propose a layout of analysers and their sample conditioning system such that the length of tubing in between the sample conditioning system and the analyser shall be located in such a way that it is completely accessible to permit adjustments, calibration and maintenance.

5. ANALYSER:

5.1 The analyser shall be furnished with all the necessary equipment to properly analyse the sample.
5.2 Material of construction for the components in contact with the sample stream shall be SS316 except where the stream composition requires other material.

5.3. The detector cells shall be of a type that will provide adequate separation of components, minimize analysis time, minimize maintenance time and meet the performance requirements of this specification.

5.4. The analyser system temperature shall be controlled by an accurate (V1EC) electric heating system to ensure the proper sample separation and minimize the analysis time.

5.5. A shutdown switch shall be provided to protect the analyser from the loss of carrier gas or loss of fuel gas.

5.6 Solenoid operated multi function valves for sample inlet and column switching shall be provided.

6. PROGRAMME / CONTROLLER

6.1 The programmer / controller shall be microprocessor based and shall be furnished with all the equipments necessary to properly control the analysis cycle, the automatic zero adjustment circuit, the calibration of the analyser and programmer systems and the transition of data to a DCS or digital computer and any require peripheral equipment.

6.2 Visual read out using a digital indicator shall be provided to identify each component being analysed and each step in the program as well as displaying the latest readings.

6.3 Peak peakers and long term memory circuit boards shall be provided for each component of the interest.

6.4. All program data tables shall be capable of field modification without user knowledge of higher level programming. A key lock switch or field alter able password shall be provided to limit access to system software by unauthorized personnel.

6.5. The application program in the analyser shall be retained for a minimum of six months without external power by the use of EEPROM or Battery back-Up. An EEPROM program cartridge interface shall be provided for program loading.

6.6. Maintenance diagnostics shall be included in the software system to allow rapid trouble shooting in the event of system mal-function. Alarms in the English language shall be provided to notify the operator in the event of the mal-function. Allow carrier flow alarm shall be included.

6.7. The stream number shall be printed-out on each analysis report.
7. ELECTRIC WIRING- SIGNAL CONTROL AND POWER:

7.1. Contractor's scope of supply and work shall include all cabling and wiring inside the analyser shelter.

7.2. Contractor shall provide an explosion proof (Exd) power distribution box for power supply to various analyzers. This box shall be certified by a statutory body for use in hazardous area. The box shall have copper bus bars for distribution of power supply to various consumers.

7.3. Power supply to individual consumer shall be by dual pole, dual element circuit breakers. These circuit breakers shall be in explosion proof (Exd) construction certified by a statutory body for use in hazardous area and shall be mounted near the equipment served and shall have engraved plastic tag plates.

7.4. All cabling and wiring shall conform to API-RP-550. Signal and power cabling / wiring shall be segregated and run in separate raceways with separation distances as recommended per API-RP-550.

7.5. All cables shall be armoured, flame. Retardant PVC insulated, 600 Volt grade, stranded copper conductor. Signal cables shall be twisted pair shielded.

7.6. Conductor size for power cables shall be 2.5 sq.mm (min.) and for signal cable it shall be 1.5 sq.mm.

7.7. Colour coding for power supply wiring shall be red for phase, black for neutral and green for earth.

7.8. Contractor shall provide junction boxes for signal and control cables separately which shall serve as interfaces for cables going to remote control room. These junction boxes shall be explosion proof (Exd) certified by statutory body for use in hazardous area.

7.9. Wire termination shall be done using self insulating crimping lugs.

7.10. All cables, wires shall be provided with identification ferrule (one piece ferrule / cylindrical ferrules for proper identification.

7.11. Terminal strips shall be provided with identifying terminal numbers, as required. Terminals shall be screw and strap compression type.

7.12. 20% spare terminals, cable entries with cable glands, relays and other components wired up to terminals shall be provided..

8. COMPRESSED GAS CYLINDERS AND THEIR HANDLING:
8.1 Each analyser shall be provided with the following compressed gas steel cylinders.
   
   a. Carrier gas and fuel gas (wherever required) with dual manifold cylinders configuration.
   
   b. Calibration gas sample bottles.

8.2 Fuel gas and Carrier gas cylinders and as sociated manifolds shall be located on a
concrete pad outside the analyser building. The gas cylinder manifold shall be arranged
so that one cylinder may be replaced while the analyser remain in operation on the other
cylinder.

Cylinders shall be sized 1A (225 mm diameter x 1300 mm long) and shall be supplied
with auxiliaries such as fittings and two stage regulators.

8.3 Calibration gas cylinders shall be located outside the analyser shelter. Contractor shall
include a drawing showing the layout of cylinders.

8.4. Racks shall be provided to support cylinders, piping, valves and pressure regulators
associated with high pressure gas cylinder manifold system. Each cylinder in the system
shall be secured to the rack by a separate chain or clamp.

8.5. A pressure relief valve, vented to a safe location outside the building shall be installed on
the low pressure side of the pressure reducing regulator of each cylinder. Vent piping
shall be installed in a manner to prevent the entry of bugs or moisture into the outlet of th
event. This vent shall be in addition to the analyser vent.

8.6. All pressure regulators shall be two stage type. A sign identifying the type of gas applied
to a manifold shall be placed above each cylinder rack.

8.7. The location and separation of hydrogen manifold from other flammable gas manifolds
shall be in accordance with NFP A50A-1973 section 52 and 61.

8.8. All tubing between the cylinders to the analysers shall be complete and easily removable
from each and either end .

8.9. Contractor’s quote shall include fuel, carrier and calibration gas cylinders as necessary,
as a minimum, for:

   i) the field testing, commissioning and final acceptance
   
   ii) One year from the date of acceptance.
8.10. The calibration gases shall be of high purity, at least better than the specified accuracy and precision values for analysers. It's preferable to prepare calibration gases by Gravimetric method.

8.11. The concentration of calibration gases must remain constant for a period of at least one year.

8.12. The material of construction of cylinders shall be suitable for maintaining stability of the calibration gas mixture for the specified time. Contract or may quote for the staggered' deliveries wherever calibration mixture is not stable.

8.13. The contract or must submit the following certificates from any recognized certifying agency / laboratory;

i) Accuracy / Precision of the calibration gas.

ii) Stability of sample for at least one year.

8.14. Contractor shall forward all the details including the source of supply, certifying agency, cylinder size and volume, sample pressure, dew point, regulator type and make etc.

In addition contract or must furnish calculations for number of cylinders quoted of each type. For calibration gas cylinders, consider calibration once in every 8 hours.

9.0 SAFETY REQUIREMENTS:

9.1. Hazardous Area Protection:

a The analyser shelter shall be an unclassified area. Positive pressure and ventilation from a clean air source shall be provided to achieve this classification.

b It is intended to operate the analysers even during the ventilation failure, hence it is required that all analysers shall be suitable for hazardous area.

c All the electrical fittings provided in the analyser shelter shall be explosion proof type. However, a safety system shall be provided by the contractor to switch off power supply to all electrical equipments and accessories not suitable for hazardous area in case of ventilation failure. To do this it shall be ensured that all analysers continue to work safely even under these conditions.

d All junction boxes, power distribution cabinets, LEL detectors and their panel and other safety devices shall be suitable for the hazardous area certified by a statutory body.

9.2. Grounding:
REQUIREMENTS FOR ANALYSER SYSTEM

a All electrical equipment in the analyser house / shelter and outside shall be grounded properly.

b Cylinder racks, sample conditioning enclosures, analyser racks, shall also be grounded directly to the AC ground bus.

c All necessary grounding bus requirement for Equipment grounding and signal shields shall be provided by the contract or in the analyser shelter. Contractor shall also provide all earthing arrangements inside the analyser shelter.

9.3. **Combustible Gas Detection System (LEL Detectors):**

a Contractor's scope includes of supply and installation of combustible gas detectors with associated monitoring system for the analyser shelter.

b Combustible gas detectors shall monitor all inlet air in take points. The detectors shall be calibrated to give alarm and high alarm at 20% and 40% respectively of the component with the lowest LEL in the area. On the occurrence of high alarm the ventilation system shall be shut-off. Contractor shall provide potential free DPDT contacts rated at 230 V AC 5 Amp for connection to ventilation system.

c Shutoff of ventilation system shall be based on 2 out of 3 voting, which means that only if two detectors out of the three provided indicate a high LEL, trip shall provided.

d Additionally, combustible gas detectors shall monitor the analyser shelter interior and exhaust air. These detectors shall give alarm and high alarm as mentioned above, however no shut off of ventilation system shall be required.

e Contractor shall calculate total requirement of combustible gas detectors along with their location.

f The monitors for LEL detectors shall be provided with malfunction, warning and danger lights and a 0 to 100% indicator.

g Contractor shall provide grouped high alarm and high-high alarm SPOT contacts rated for 230 V AC 5 Amp for repeat alarms in remote control room.

h The monitors for LEL detection system shall be installed in a panel which shall be pressurised as per NFPA 496 type ‘Z’ purge.

9.4 **Fire / Smoke detection**
REQUIREMENTS FOR ANALYSER SYSTEM

a Contractor's scope shall include supply and integration of fire detectors / smoke detectors (Ionisation type) within the analyser shelter. The no. of shelters shall be decided by the contractor based on the shelter size and coverage of area with in the shelter.

b The monitors for the fire detection shall be installed in a pressurized / purged panel as per NFPA 496 type Z purge. This may be shared with LEL monitor panel.

C The signals from the fires system monitor shall be provided for :

- One contact for alarm on the warning panel.
- One contact each for repeat alarm in the control room DCS and fire panel of Electrical section.

9.5 Oxygen gas monitoring

a Contractor shall provide a maximum of two nos. of oxygen gas monitoring system for sensing deficiency of oxygen within the shelter.

b In case the monitors show low concentration of oxygen within the analyser shelter, an alarm shall be initiated on the warning panel. The repeat alarm shall also be provided for DCS in the Main control room.

c Oxygen monitors should be located in purged panel as per NFPA 496 type Z purge. These may be located in the same panel where LEL detectors are installed.

9.6 Warning Panels:

a Contractor shall provide warning panels for audio visual alarming of hazardous conditions inside the analyser shelter. One such panel shall be installed by contract or on each of the external walls of the analyser shelter where entrance doors are provided.

b The warning panel shall provide the following audio-visual alarms:

i Presence of combustible gases inside the analyser house / shelter.

ii Loss of analyser house / shelter pressurization

iii Ventilation system failure

iv Fire / smoke within the shelter
v Oxygen deficient within the shelter

c For alarming of analyser shelter pressurization failure contractor shall provide an explosion proof pressures switch for sensing analyser shelter inside pressure.

d These warning panels shall be of explosion proof (Exd) construction certified by a statutory body for use in hazardous area.

10.0 FACTORY TESTING AND ACCEPTANCE:

10.1. The analyser systems shall be thoroughly checked and tested prior to shipment to assure correct design, construction and proper operation.

10.2. The Owner / Consultant reserves the right to be involved and satisfy himself a teach and every stage of inspection and testing.

10.3. During the final testing vendor shall test and demonstrate to the Owner / Consultant, the functional integrity of all analysers, sampling systems and all other hardware. Repeatability test shall be performed on all analysers for a test period of 24 hours. No material or equipment shall be transported until all required tests are successfully completed and certified. Ready for shipment 'by the Owner / Consultant. Softwares, if involved, shall also be tested.

10.4. Contractor shall submit schedule of factory testing and inspection.

10.5. After placement of order vendor shall submit his factory testing and customer acceptance procedure for Owner's / Consultant approval. This document shall contain the information related to each test e.g. purpose of test, definition, test procedure, results expected and acceptence.

10.6. Owner / Consultant has every right to add or delete any test in vendor's test procedure and acceptance criteria. The system shall be tested and accepted as per the approved testing procedures and acceptance criteria. The cost of performing all tests shall be borne by the vendor.

10.7. Contractor shall notify the Owner / Consultant atleast three weeks prior to final system testing at vendor's works. In the event that representatives of Owner / Consultant arrive and the system is not ready for testing, the contractor shall be liable for back charging for any extra time and expenses incurred by the Owner.

10.8. It shall be contractor's responsibility to modify and / or replace any hardware, equipment or analyser if the specified functions are not completely achieved satisfactorily during factory testing and acceptance.
11.0 INSTALLATION, TESTING AND COMMISSIONING:

11.1. Contractor shall provide the services of his installation team which would install the equipment in the analyser house / shelter and in the field, lay the tubing from sample probe to analyser house / shelter, lay the interconnecting cabling tubing inside the analyser house / shelter, perform system check outs, test and commission the entire system.

11.2. All technical personnel assigned to the site by the vendor shall be fully conversant with the system supplied and shall have capability to bring the system on-line quickly and efficiently with a minimum of interference with other concurrent construction and commissioning activities.

11.3. Contractor's responsibility at site shall include all activities necessary to be performed to complete the job including:

a. Receipt of all analysers and related hardware, and checking of completeness of supply. In case of shelters, verification of all analysers and accessories duly installed tubed and wired.

b. Installation of all analysers, and other associated equipment including all safety equipment like LEL detectors, annunciators, panels etc., all auxiliaries like power supply distribution boxes, all interconnecting tubing / piping etc. so as to complete the job in case of analyser room (not shelter).

c. Installation of sample probes, pressure reducing stations, sample conditioning systems, interconnecting tubing, heat tracing etc.

d. All analyser sample stream bypass, vent and drain tubing/piping.

e. Termination of all field cables or cables to control room, ferruling} tagging of interconnecting cables in analyser house/shelter.

f. Interconnection cabling inside the analyser house/shelter.

g. All civil works like grouting, fixing etc and patch up work where vendor is likely to remove the plaster and shall make holes in the walls, floor or ceiling.

h. Checking of interconnections, hardware configuration, overall system functioning. Leakage rate test. J Liaison with vendor's home office.

k. Field testing.

l. Commissioning of the complete analyser system.
11.4 System Check-outs:

a. Checking of all interconnections, configuration and overall system functioning.

b. Any discrepancy found during checking shall be brought to the notice of Engineer-in-Charge.

c. All the check-outs shall be performed in the presence of Owner! PMC authorized representative. All readings shall be recorded on a suitable format and shall be submitted for approval.

d. After system checking is completed, contractor shall connect back any terminal or tubing or connection removed for loop checking.

e. All the equipment shall be checked thoroughly after its receipt at site. The tests, as a minimum, shall include;

i. Visual and mechanical testing

ii. Complete system configuration loading

iii. Calibration of all analysers, and other related equipment.

iv. Demonstration of all system functions.

V. Demonstration of all system diagnostics.

vi. Checking of correct change of redundant devices.

vii. Demonstration of analyser accuracies, linearities, repeatabilities, response time etc.

viii. Demonstration of proper operation of system at specified voltage supply specifications.

ix. A leakage test shall be conducted on entire system. Maximum permissible leakage rates shall not exceed 5% per hour of specified designed pressure.

12.0 TRAINING:
Contractor shall be responsible to train the Owner / Consultant personnel in the field for
maintenance of hardware and software. The outline of each course including the course
contents and the duration shall be forwarded by the vendor alongwith the offer.

13.0 DOCUMENTATION:

Contractor shall furnish all the manuals, including for maintenance and operation,
necessary to test, operate and maintain etc the analysers and other related equipment,
hardware and software.

14.0 ENGINEERING DRAWINGS:

14.1 Contractor shall provide a complete set of drawings covering each part of supply for
Owner / Consultant record. The contract or is required to include Owner's project number
on each of his drawing.

14.2 All field modifications shall be carefully recorded by the contractor's installation and
commissioning personnel and changes shall be incorporated into the final drawings.

15.0 FINAL ACCEPTANCE TEST:

The Owner. Will take over the system from the contractor after the final acceptance test,
which is defined as successful uninterrupted operation of the integrated system for three
weeks with desired accuracy and repeatability. Contractor's personnel shall be present
during the test. Any malfunctioning of the system components shall be replaced / repaired
as required. Once the system failure is detected, the acceptance test shall start all over
again from the beginning.

16.0 TESTING AND CALIBRATION EQUIPMENT:

Contractor shall make available all consumables including calibration gas cylinders,
instruments and equipments necessary for testing, calibration, maintenance etc. as
defined by the ' scope of work'. All instruments and equipments used for the above
purpose shall be of standard make with accuracy better than the accuracy expected from

the calibrated / tested equipments and shall be certified by National Physical Laboratory
or other equivalent agencies.

17.0 SPARE PARTS:

Contractor shall quote separately for spare parts required for a two year period of
operation for the complete analyser system and the associated auxiliaries offered.
Contractor shall enclose a list of spare parts quoted along with the offer.
18.0 MAINTENANCE CONTRACT:

Contractor shall quote separately for maintenance contract after warranty period for two years based on per day rate for each category of personnel required. The personnel deployed shall have thorough knowledge of the system and at least two years of experience as maintenance of similar system.

19.0 PACKING AND SHIPPING INSTRUCTIONS:

19.1. All materials used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be recognized brands and shall conform to the best standards in the areas for the articles which are being packaged.

19.2. Workmanship shall be in accordance with best commercial practice with the requirement of applicable specifications. There shall be no defect; imperfections or omissions which would tend to impair the protection of the package as a whole.

19.3. The package shall be suitable for storing in tropicalised climate as per specified ambient conditions.

19.4. Shipment shall be thor oughly checked for completeness before final packing and shipment. Contractor shall be fully responsible for any delay in installation or commissioning schedule because of incomplete supply of equipment.
STANDARD SPECIFICATION FOR
STACK ANALYSERS
Abbreviations:

AARH  Arithmetic Average Root Height
CCE   Chief Controller of Explosives
CIMFR Central Institute of Mines and Fuel Research
ERTL  Electronics Regional Testing Laboratory
DGMS  Director General of Mine safety
CRCA  Cold Rolled Cold Annealed
DC    Direct Current
DCS   Distributed Control System
HVAC  Heating Ventilation and Air conditioning
IR    Infrared
LCD   Liquid Crystal Display
LED   Light Emitting Diodes
MAWP  Maximum Allowable Working Pressure
MOC   Material of Construction
PTFE  Poly Tetra Fluoro Ethylene
NPT   National Pipe Thread
RAM   Random Access Memory
RTU   Remote Transmission Unit
SS    Stainless Steel
UV    Ultraviolet
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1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the data sheets, covers the requirements for the complete design, materials, nameplate marking, and inspection, testing and shipping of stack gas analysers.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser’s enquiry:

- ANSI/ASME American National Standards Institute/ American Society of Mechanical Engineers.
- B 1.20.1 Pipe Threads. General Purpose (Inch)
- B 16.5 Steel Pipe Flanges and Flanged Fittings. NPS ½ through NPS 24.
- B 16.20 Metallic Gaskets for Pipe Fittings, Ring Joints, Spiral and Gasketed.

API American Petroleum Institute
- Manual on Installation of Refining Instruments and Control System
- RP 551 Process Measurement Instrumentation
- RP 552 Transmission System
- RP 554 Process Instrumentation and Control
- RP 555 Process Analysers

ASTM 693 Standard Practice for cleaning methods and cleanliness levels for material and equipment used in oxygen-enriched environment.

EN 50020 Electrical Apparatus for potentially explosive atmospheres-Intrinsic safety ‘i’

EN 10204 Inspection Documents for Metallic Products.

IEC-60079 Electrical Apparatus for Explosive Gas Atmosphere.

IEC-60529 Degree of Protection Provided by Enclosures. (IP Code)

1.1.2 Bids

1.2.1 Vendor’s quotation shall be strictly as per the bidding instruction to vendor attached with the material requisition.
1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:

a) Compliance to the specifications.

b) A detailed specification sheet for each analyser, which shall provide information regarding type, materials of construction, performance specification and accessories of analyser. The material specification and units of measurement for various parts in vendor’s specification sheets shall be to the same standards as those indicated in purchaser’s data sheets.

c) A detailed drawing showing various components of sample conditioning system and their piping/tubing hook-up arrangement including sample return, vent, utilities connection and requirement of heat tracing (i.e. electrical or steam tracing), as necessary.

d) Sample transportation time calculations for the specified distance between sample point and analyser indicating sample flow rate and the recommended size of the sampling tube.

e) Calibration gas cylinder calculations considering six months of continuous operation with once in a fortnight calibration. The calculation sheet shall indicate the rate of gas consumption and specification of gas es including composition, concentration, accuracy and shelf life of calibration blend.

f) Proven references for each offered model of analyser inline with clause 1.2.3 of this specification.

g) A copy of approval for intrinsically safe/flameproof enclosure, whenever specified, from local statutory authority, as applicable, such as Chief Controller of Explosives (CCE), Nagpur or Director general of Mines Safety (DGMS) in India, along with:

i) Test certificate from recognised house CMRI/ERTL etc. for flameproof enclosure as per relevant Indian Standard for all Indian manufactured equipments.

ii) Certificate of conformity from agencies like CSA, BASEEFA, PTB, LCIE, FM, UL etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

h) Utility requirements and their consumption i.e. instrument air, cooling water, steam etc. along with their process conditions like flow, pressure and temperature.

i) Power consumption for each analyser and its accessories.

j) HVAC requirements i.e. heat load, humidity particulate/chemical filtration etc.

k) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason, they must include a list of deviations tag number wise, summing up all the deviations from the purchaser’s data sheets and other technical specifications along with the technical reasons for each of these deviations.

l) Catalogues giving detailed technical specifications, model decoding details and other related information for each type of analyser and accessories covered in the bid.
1.2.3 All items, as offered, shall be field proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date for the analysis as specified in the purchaser’s data sheet. Items with proto-type design or items not meeting provenness criteria specified above shall not be offered.

1.2.4 All documentation submitted by the vendor including the quotation, catalogues, drawings, installation, operation and maintenance manuals, etc shall be in English language only.

1.2.5 Vendor shall also quote for the following:

   a) Complete calibration kit consisting of calibration gas cylinders, pressure regulators, gauges, cylinder gas piping manifolds and driers, (as required) etc. as a minimum for each analyser. In case of dual range analyser, separate calibration standards shall be provided for each range. For the purpose of calculating requirement of zero and span calibration samples/gases, consider calibration time of 30 minutes every fortnight for each analyser for a period of six (6) months of continuous operation.

   b) Consumable spares for the duration of six months with list of items as per vendor recommendations for each analyser system, unless otherwise specified in job specification.

   d) Start up and commissioning spare parts for each analyser/analyser system as per vendor recommendations. However this list of spare parts must include 5% or minimum one of each type of following spare parts:

   - Solenoid valve
     - Pressure regulator
     - Filters
     - Temperature controller
   - IR/UV Source (lamp)
     - Peristaltic pump
     - Set of fuses
     - Set of o-rings
     - Tubing and tube fittings (sizes smaller than 6 mm or ¼”).

Additional spare parts, if required, during start-up and commissioning, even though not listed in the list of start-up and commissioning spares mentioned above, shall be supplied by the vendor without any implication.

   d) Any special instrument or tool needed for testing, calibration and maintenance of the analyser such as spanner set (for tubes smaller than 6 m m or ¼”), non-magnetic tools, bubble rotameter etc.

   e) Training at vendor works and at site as specified in job specifications.
f) Two years operational and maintenance spares for each analyser and its accessories as per vendor recommendations, which shall include spare parts like electronic modules, temperature controller, power supply module, flow meter, solenoid valve, pressure regulator, local indicator, tubes, fan assembly, sample cell, detector assembly, UV/IR source/lamps, set of o-rings, set of fuses etc.

1.3 Drawing and Data

1.3.1 Detailed drawing, data, catalogues and manuals required from the vendor are indicated by the purchaser in the vendor data requirement sheets attached with the enquiry. The required number of reproducible, prints, and soft copies shall be despatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data, installation, operation and maintenance manual etc., submitted by the vendor after placement of purchase order shall include the following, as a minimum;

a) Specification sheet for each analyser and its accessories.

b) Certified drawings for each analyser and its accessories, tag number wise, which shall provide the following information:

i) Overall dimensions in millimetres.

ii) Sampling system details identifying each component with make and model number, process connection, utility connection, calibration sample/gas connection, heat tracing requirements, sample vent and fast loop details etc. The flow, pressure and temperature at interface and other appropriate location must be shown in the sampling system drawing.

iii) Detailed interconnection drawing of each analyser identifying each component with terminal number, cable type, and cable size and cable entry details. The interface details shall be clearly identified in the drawing.

iv) Grounding details.

v) Power supply distribution details.

c) Programming/configuration data for each analyser, as applicable.

d) Serial interface specification including its configuration data (addresses) for host communication.

e) Power consumptions and utility requirements.

f) Calibration curves and calibration data for each analyser.

g) Zero and span calibration gas specification including composition, shelf life time and accuracy.
h) Copy of type test certificates.
   i) Copy of the test certificates of all the tests indicated in clause 4.0 of this specification.

j) Installation procedure for each analyser and their accessories.
k) Calibration and maintenance procedures including replacement of its parts/Internals wherever applicable.

1.4 Definitions

1.4.1 The following definitions shall apply for analysers and their accessories:

a) **Transportation time**
   Transportation time is the time interval between a step change in the process fluid composition in the process line and the initial analyser response (excluding analyser response time).

b) **Response Time**
   The time interval between the Initial response of the analyser and the time required for the analyser output to reach a value of 90% of the final output value for a step change in sample quality.

c) **Time Constant**
   The analyser response to reach a value of 63% of the final output value for a step change in sample quality is called the analyser time constant.

d) **Repeatability**
   Repeatability of a measurement is the band of values within which an analyser repeats its measurement when the same sample is applied to it. The short termed repeatability is generally determined by multiple readings of a sample during calibration and is usually true random error over short period of time if external influences like pressure and temperature etc remain constant.

   It is also defined as the difference between two successive analyser results that would be exceeded in the long run in only one (1) case in twenty (20) when a single analyser system is operated on a flowing sample of uniform quality.

e) **Sensitivity**
   The sensitivity of an analyser is a measure of an analyser's ability to detect a least change in concentration of a measured component that is not masked by the background noise.

f) **Accuracy**
   Accuracy of a measurement is the measure of how close the measured value is to the true value of the sample. For all type of analysers, accuracy is primarily a function of the accuracy of the standards used for calibration.

g) **Analyser Rack**
An open analyser mounting structure with/without canopy used for mounting analysers, sample handling system and their accessories individually or together in combination.

h) **Analysers Cabinet**

Small housing, in which analysers are installed individually or grouped together. Maintenance is performed from outside the cabinet with door(s) open.

### 2.0 DESIGN AND CONSTRUCTION

#### 2.1 Analyser Requirements

2.1.1 The type of analyser and its measuring principle is specified in the purchaser’s data sheet. Accessories and equipments as required to make online analysis complete are also specified in the data sheet. In general, the scope shall include the following:

a) Sample probe and sampling system, as applicable

b) Analyzer complete with all hardware and software consisting of detector, transmitter and associated equipments.

c) Fast loop and Sample return system, as applicable

d) Calibration and maintenance equipment.

e) Gas cylinders for zero and span calibration.

Unless otherwise specified the scope shall also include supply of all interconnecting tubing, piping, fittings, heat tracing equipment etc., excluding sample return piping from analyser battery limit to sample return header.

In-situ analysers when specified may not include sampling system.

2.1.2 Analysers and its related equipments directly connected to process line and In-situ analysers shall be capable of withstanding line pressure/vacuum and temperature conditions specified in the purchaser’s data sheet.

2.1.3 The analyser design and design of sample handling system shall be such that components or any sub-assembly that requires removal, shall be possible without any need to disassemble any other component. Such components shall include items like stream selector valves, (when applicable) filters, pressure regulators, flow-indicator, detector, electronic modules etc.

2.1.4 Analyser shall be microprocessor based with state-of-the-art technology and shall be capable of being configured from analyser front panel locally using built-in keyboard. When specified, it shall also be possible to configure the analyser from remote through a separate terminal.

2.1.4.1 The programmer/controller shall be microprocessor based and shall be furnished with all the equipments necessary to properly control the analysis cycle, the automatic zero adjustment circuit, the calibration of the analyser and programmer systems and the transition of data to ADSU or DCS and any require peripheral equipment.

2.1.4.2 Visual readout using a digital indicator shall be provided to identify each component
being analysed and each step in the program as well as displaying the latest readings.

2.1.4.3 Peak peaker and long term memory circuit boards shall be provided for each component of the interest.

2.1.4.4 All program data tables shall be capable of field modification without user knowledge of higher level programming. A key lock switch or field alterable password shall be provided to limit access to system software by unauthorized personnel.

2.1.5 The configuration related data of the analyser including set range shall be stored in a nonvolatile memory such that this data remains unaffected by power fluctuations or power off condition. In case vendor’s standard product stores configuration data in battery backed RAM, analyser shall have facility to provide battery drain alarm as diagnostic maintenance message.

2.1.6 The span of the analyser shall be field adjustable from the analyser front without opening the analyser enclosure. In case, separate device is required to make such a change, the same shall be included by vendor in their scope of supply.

2.1.7 Analyser shall run diagnostic subroutines on continuous basis and shall be able to provide diagnostic alarms related to analyser optics, detector and electronics, as and when any failure/malfunction is detected.

2.1.8 Analyser shall have an integral output meter with digital readout in engineering units.

2.1.9 All interconnecting wiring shall be colour coded / numbered and terminal blocks be clearly identified.

2.1.10 The analyser shall be capable of providing the following outputs:

a) Isolated 4-20 mA DC current output for each analysed component. Smart or field bus output shall be provided when specifically indicated in the purchaser’s data sheet.

b) RS485 serial output with MODBUS (RTU) protocol, whenever serial output is specifically indicated in the purchaser’s data sheet. The serial output signal shall contain analyser data of component of interest and diagnostic alarms, as a minimum.

c) SPDT contact outputs for various diagnostic alarms (as applicable) such as:

   i) High or low set point alarm as measurement
   ii) Analyser failure
   iii) Low sample flow
   iv) Temperature control failure

Any other alarm contact, either specifically indicated in purchaser’s data sheet or available as standard with the analyser, shall also be provided.

Unless specified otherwise, all contacts shall be normally closed type (contact open in alarm) and shall be rated for 110V AC 5 Amperes.

2.1.11 Statutory Regulatory Compliance
The design of analysers shall be in compliance with the electromagnetic compatibility requirements as per IEC-61000-4-X.

2.1.13 **Material of Construction**

2.1.13.1 Unless otherwise specified, the material of construction of all components wetted by the sample shall be SS 316, as a minimum. Vendor must ensure the compatibility of material of each component with the process fluid.

2.1.13.2 Material of all soft parts like diaphragms and o-rings shall be of PTFE. Other vendor standard materials can also be acceptable provided these are compatible with the specified process conditions.

2.1.13.3 The material of construction of all non-wetted parts shall be as per manufacturer’s standard. However, non-metallic materials for casings, enclosures and instrument covers shall be avoided.

2.1.14 **Power Supply**

2.1.14.1 Unless indicated otherwise, the analyser including the sample handling system shall operate at 110V 50Hz power supply.

2.1.14.2 The analyser performance shall be within the specified limits when the supply voltage varies by ±10% of specified value and supply frequency varies by ±3 Hz of specified value.

2.1.14.3 Electrical tracing when specified, shall operate at 230V 50 Hz supply. 230V 50Hz power supply shall also be used for analyser cabinet/panel lighting and air conditioning unit, when specified.

2.1.15 **End Connection**

2.1.15.1 Unless otherwise specified, the following shall govern:

a) Threaded connections shall be NPT to ANSI/ASME B 1.20.1.

b) Flanged connection shall be as per ANSI/ASME B16.5.

c) Flange face finish shall be serrated concentric to clauses 6.4.4.1, 6.4.4.2, and 6.4.4.3 of ANSI/ASME B 16.5. The face finish shall be as follows:

\[
\begin{align*}
125 \text{ AARH} & : 125 \text{ to } 250 \text{ AARH} \\
63 \text{ AARH} & : 32 \text{ to } 63 \text{ AARH}
\end{align*}
\]

d) Ring type joint flanges shall have octagonal grooves as per ANSI/ASTM B16.20.

2.1.15.2 End connection of sizes 6 mm or below shall be suitably protected against damage.
2.1.15.3 All end connections shall be clearly identified by attaching labels or stainless steel plate of suitable size.

2.1.16 **Enclosure Type**

2.1.16.1 Analyzer enclosure and related accessories shall be suitable for the electrical area classification indicated in purchaser's data sheets. Unless otherwise specified, the enclosures shall comply with the following standards:

- **Weather proof housing**: IP 65 as per IEC-60529 / IS-13947
- **Flame proof housing**: Flame proof Ex (d) as per IEC-60079 / IS-2148
- **Purged Enclosure**: NFPA 496

Flameproof and purged equipment shall also be made weatherproof.

2.1.16.2 In addition to meeting weatherproof requirements specified in clause 2.1.15.1 of this specification, intrinsically safe analysers shall meet the requirements specified in EN 50020 and shall be certified for the area classification specified in the purchaser's data sheet.

2.1.16.3 Analyser where air/nitrogen purge is provided, purge shall be as per NFPA 496 Type X. Analyser power shall cut off in case of purge failure. Purge failure alarm shall be provided for purchaser use.

2.1.16.4 Separate cable entries shall be available in the analyser/enclosure for power and signal cable.

Unless otherwise specified, following shall apply:

a) Cable entry and terminal size for power cable shall be ¾” NPT(F) cable entry other than ¾” NPT (F) shall be provided when specified.

b) Cable entry for Serial cable/signal cables (Signal output) shall be ½” NPT (F).

c) Cable entry for multi-pair signal cables (Multiple output) shall be 1½” NPT (F).

Reducer fitting may be provided when the analyzer standard cable enters are different than those specified.

2.1.16.5 All enclosure entries including sample, utilities, cables etc. shall be clearly identified by attaching label or stainless steel plate of suitable size.

2.2 **Sample Handling System**

2.2.1 The sample handling system shall consist of primary sample conditioning near sample take off point, sample transportation line, secondary sample conditioning near the analyser, sample return, sample/analyser vent and sample drain/recovering system, as applicable.

The primary sample-conditioning unit shall be a fabricated assembly and shall be mounted on a stainless steel plate suitable for surface mounting.
Secondary sample conditioning shall also be a fabricated assembly and shall be mounted either on a stainless steel plate or within an enclosed cabinet/box with a viewing window.

2.2.2 Stream sampling shall be continuous and analyser shall be located as near as possible to the sample take-off point. Where the analyser is located away from the sample take-off point, vendor shall design the sample fast loop (bypass loop) as part of sampling system. Design shall ensure that the sample drawn is true representative of the stream to be analysed.

2.2.3 In general, sampling systems shall be designed and constructed in accordance with API-RP-555. The design of sampling handling system shall consider the following factors, as a minimum:

a) The pressure/vacuum-temperature conditions required for the analyser.
b) Interfering components in the process sample.
c) Normal and abnormal sample compositions.
d) Fouling sample conditions e.g. polymer formation or presence of solids etc.
e) Transportation time requirements.
f) Utilities available and their process conditions.

2.2.4 Unless otherwise specified, material of all components wetted by sample shall be suitable for the process fluid and sample process conditions specified in the purchaser’s data sheet. The material of construction for all wetted parts shall be, 316 SS, as a minimum.

2.2.5 Sampling system shall include all elements as necessitated by the process conditions indicated in the purchaser’s data sheets, to make the sample suitable for the analysis. This shall include but not limited to filters (coarse and fine), pressure regulators, relief valves, flow indicators, flow controllers, temperature indicators, scrubbers, heaters, coolers, dryers, sample pumps, aspirators etc.

Each sampling system element shall be capable of being removed without disassembling the entire system.

2.2.6 Sample probe shall be provided by the vendor to obtain representative sample from the stack. The sample probe shall be inserted in the stack through an isolation valve (ball or gate valve), which shall be part of vendor’s scope of supply. The probe design shall ensure the following:

a) On-line removal and insertion of the probe with non-fly-off design.
b) Unless otherwise specified, end connection for installation in the line shall be 4” flanged with type and rating as specified in purchaser’s data sheet. The line isolation valve shall also be of the same size and rating as probe end connection.
c) The probe diameter shall be such that it can be easily inserted or removed through the line isolation valve when in fully open condition.
d) The length of the probe shall be selected considering its insertionupto the middle third of the stack. For the purpose of calculating probe length, consider nozzle length as 200 mm.

2.2.7 Sampling system shall include a sample block valve on all process sample line. The block valve shall be provided meeting the following requirements:
a) The block valve shall be located immediately after the sample probe.

b) Where purchaser’s data sheets do not indicate the requirement of sample probe, the block valve shall be provided in the sample line as a part of primary sample conditioning unit.

c) The size of the sample block valve shall be as per the sample line size while the rating shall be as specified in the purchaser’s data sheet.

2.2.8 The size of the sample tubing shall be decided by the vendor considering:

a) The distance between sample take off and analyser specified in purchaser’s data sheet.

b) The specified sample transportation time.

c) Pressure at the sample take off point.

Where no transportation time is specified in the purchaser’s data sheets, vendor shall consider the sample transportation time as 60 seconds.

2.2.9 Where sample is required to be transported in hot condition, sample shall be drawn using prefabricated heated tubes. The heated medium shall be either steam or electric power as specified in purchaser’s data sheet.

Heating shall be controlled such that the sample temperature is maintained typically around +20°C above the sample dew point.

2.2.10 When fast loop is specified or recommended by vendor, vendor shall provide flow meter for sample bypass flow. Sample return line to process shall be provided with isolation valve and check valve. Vendor shall ensure that return pressure of the sample shall be higher than the pressure of the process return point specified in purchaser’s data sheet.

2.2.11 Sampling system shall include provision for connecting calibration sample/gases in auto or in manual configuration as specified in purchaser’s data sheet. When no specific requirement is indicated, the provision shall be made for manual configuration only.

2.2.12 Whenever auto-calibration requirement is specified in the purchaser’s data sheet, it shall be possible to initiate auto calibration cycle at preset time interval defined by user either manually via the analyser keyboard or remotely through an external contact.

The sample handling system shall be designed to include all hardware and/or software to meet this requirement. The analysed component concentration output shall remain at the last good measured value during auto calibration cycle.

2.2.13 Unless specified otherwise, analysers with common take off shall have separate sample handling system for each analyser.

2.2.14 Filters shall always be provided in dual configuration. It shall be possible to replace the filter without upsetting the operation of the analyser.
2.2.15 Unless specified otherwise, sample lines used for carrying samples for more than one analyser shall be provided with sample pumps in dual configuration. It shall be possible to remove or insert the pump without upsetting the sampling system.

2.2.16 A suitable restriction orifice shall be provided in each sample line to limit the sample flow exceeding thrice the normal flow in the event of tube rupture or opening of tube down the line.

2.2.17 Sample Extraction Techniques:

Sample extraction shall be any one of the following unless otherwise specified in the Data sheet.

2.2.17.1 Dilution Technique.

a) Instrument air shall be provided by the purchaser and the specification shall be as specified elsewhere. Vendor shall consider the minimum pressure condition for the system design.

b) Vendor scope shall include all items/elements like dilution probe, pneumatic control module, instrument air pressure/flow controller, pressure gauge, etc. as necessary for proper system design. Additional dew point suppression of instrument air (Beyond that is specified) shall be taken care of by vendor.

c) Vendor shall select the dilution ratio depending upon their system design. Calculations for the same shall be furnished by vendor.

d) For dilution type technique, vendor must select the range of analyzers based on the dilution ratio selected.

e) Vendor shall be fully responsible to select the dilution probe with critical orifice. The material of orifice shall be ‘QUARTZ’ as a minimum. Vendor’s scope shall include supply of one spare orifice along with each sample probe clearly marking the dilution Ratio.

2.2.17.2 Hot Extraction Technique.

Vendor shall select heated sample lines (Prefabricated tubes with tracer and insulation) with electrical tracing. The temperature of the sample line shall be controlled at a temperature so as to avoid condensation in the sample lines. The temperature control unit shall also form part of vendor’s scope of supply. The sample lines shall be prefabricated tubes with electrical traces fully insulated with overall sheath of low smoke grade PVC. All such tubes should have undergone services life performance test as per IEEE 515. The electrical tracing line with temperature controller shall be suitable for the specified area classification.

2.2.18 The sample handling system shall be designed to,

Avoid plugging of sample probe and sample line even in case of;

- Failure of electrical tracing
- Failure of instrument air
- Excessive solid particles during start up or process upset condition.
Vendor shall clearly study each of these scenarios and provide automatic sample shut off and blow back facility in line with the requirements of the specified application.

2.2.19 The routing of sample transfer lines shall be done in such a way that the total length between the sampling point and the analyser sample conditioning system is minimum. Short radius bends shall be avoided to avoid excessive pressure drop.

2.2.20 Where sample pumps are used, moisture sensor shall be provided in sample handling system to cut off pumps in case of high moisture level.

2.2.21 Analyser rack and cabinet

(a) Whenever specified in the purchaser's data sheet, the analyser shall be supplied in pre-assembled, pre-tubed and pre-wired condition complete with sample handling system. The primary sample-conditioning unit i.e. conditioning at sample tap-off point, shall be supplied separately.

(b) When open rack mounted installation is specified in purchaser’s data sheet, the analyser and sample handling system shall be supplied installed in an open rack with canopy to protect the analyser from direct sunlight and rain. The open rack shall be fabricated using channels/pipes of suitable size. The material of construction shall be stainless steel. The canopy shall also be fabricated out of SS plate of 1.2 mm thick.

(c) Whenever closed cubical mounted installation is specifically indicated in the purchaser’s data sheets, analyser and sample handling system shall be supplied preinstalled in freestanding closed analyser cabinet. The analyser cabinet shall be suitable for outdoor installation and shall be provided with a key lock. Cabinet shall be fabricated out of 2.0mm SS sheet reinforced with angles of suitable sizes. Fittings and hinges shall be of stainless steel. Anchor bolts required for installation of cabinet shall also be supplied by vendor. A power isolation switch with suitable circuit breaker or fuse shall be provided for the incoming power supply. All items including analyser installed within the cabinet shall be suitable for the maximum possible temperature likely to be attained within the cabinet (i.e. with all items fully powered-on within the cabinet) and area classification specified in the purchaser’s data sheet. Heating/cooling of analyser cabinet shall be provided either when purchaser’s data sheets specify the requirement of heating and/or cooling or recommended by the analyser manufacturer or found necessary by the manufacturer to meet following requirements:

(i) The temperature induced measurement error exceeds ± 1% of full scale in the worst temperature conditions.

(ii) The maximum allowable ambient temperature condition of any component within the cabinet exceeds its limits.

Whenever cooling is specified or found necessary, vendor may select one of the following cooling methodology, unless specifically indicated otherwise:

(a) Cabinet mounted air conditioner certified for the specified area classification.
2.3 CARBON MONOXIDE, CARBON DIOXIDE ANALYSERS

2.3.1 Unless specified otherwise the CO/CO2 analysers shall be of Infra Red type.

2.3.2 IR/UV analyser shall preferably be non-dispersive type.

2.3.3 Analyser cell length shall be selected as per specified analyser component range. In case of dual range analysers, the selected cell length shall be suitable for both the ranges.

2.3.4 The analyser cell material and window material shall be suitable for the specified service. Unless otherwise specified or required otherwise by pressure-temperature conditions, the oring material shall be Teflon.

2.3.5 The analyser design shall be such that it is insensitive to source fluctuations or cell window degradation/partial cloudiness.

2.3.6 The analyser shall have built-in indicator with digital display.

2.3.7 Unless otherwise specified, analyser shall meet the following performance requirements:

- Repeatability : ± 1% of full scale or better
- Zero drift : ± 1% full span/week.
- Speed of response : less than 90 seconds for 90% of final reading.
- Linearity : ± 1% of full scale or better.

2.4 SOx ANALYSER

2.4.1 Unless specified otherwise the analyser measurement principle shall be based on UV Fluorescence. The UV source lamp shall be highly energizing, monochromatic with minimum source life of 5 years.

2.4.2 Analyser cell length shall be selected as per specified analyser component range. In case of dual range analysers, the selected cell length shall be suitable for both the ranges. The analyser cell material and window material shall be suitable for the specified service.

2.4.3 Unless otherwise specified or required otherwise by pressure-temperature conditions, the oring material shall be Teflon.

2.4.4 The analyser design shall be such that it is insensitive to source fluctuations or cell window degradation/partial cloudiness.

2.4.5 Special filters shall be offered to minimize the interference of background components.
2.4.6 Where IR type analysers are specified, the same shall meet the specification as per clause 2.3 above.

2.4.7 Unless otherwise specified, analysers shall meet the following performance requirements:

Zero/span Drift : ± 1% of full span/week
Repeatability : ± 0.5% full scale or better.
Response time overall : less than 90 seconds for 90% of final reading.
Linearity : ± 1% of full scale or better.

2.4.8 Analyzer for incinerator stack for sulphur plant (SRU)

The analyzer system design and analyzer selected for incinerator stack are suitable for the sample containing high sulphur contents. The sample handling system shall be designed for such eventuality which is likely to occur during start up or under plant upset condition.

Any one of the following techniques shall be considered meeting other requirements:

a) Dilution technique with sample handling system designed considering the worst conditions of sulphur.

b) Hot extraction technique with heated analysers.

2.5 NOx Analysers

2.5.1 Unless otherwise specified the NOx analyser measurement principle shall be Chemiluminescence type.

2.5.2 The analyser shall be complete with ozonator, mode selection chamber for NO, NO-NO2, reaction chamber and detection unit.

2.5.3 Special filters shall be offered to minimise the interference of background components, which are of least interest in process stream.

2.5.4 The analyser shall have built in indicator with digital display for measurement & instrument opacity parameters indications.

2.5.5 Unless otherwise specified the analyser shall meet the following performance requirements

Zero/span Drift : ± 1% of full span/week
Repeatability : ± 0.5% full scale or better.
Response time overall : less than 90 seconds for 90% of final reading.
Linearity : ± 1% of full scale or better.

2.6 HC Analyser

2.6.1 Unless specified otherwise the analyser measurement principle shall be based on the Flame Ionisation Detection (FID) for HC Analysers.
2.6.2 Probe length shall be provided such that 30% insertion in heater stack and shall be calculated based on the nozzle projection and shall be based on the Stack ID given.

2.6.3 Probe & Filter material shall be selected to suit the stack process condition.

2.6.4 Unless otherwise specified the analyser shall meet the following performance requirements.

- Zero/span Drift: ± 1% of full span/week
- Repeatability: ± 1% full scale or better.
- Response time overall: less than 30 seconds.
- Linearity: ± 1% of full scale or better.

2.7 Analyser Data storage Unit

2.7.1 The central analyser data storage unit (ADSU) shall be provided for the storage of data and diagnostic alarms of analysers and analyser shelter/analyser room as applicable.

2.7.2 Unless specified otherwise a common ADSU shall be provided for all the stack analysers and related analyser shelters/rooms:

2.7.2.1 Processor/Hardware for data acquisition and communication including network switches, fibre optic cables etc.

2.7.2.2 Shelter analyser console located at each shelter.

2.7.2.3 Common stack analyser system console located at control room.

2.7.3 ADSU Data Acquisition System:

2.7.3.1 The Data acquisition & Communication Hard Ware of ADSU shall be located in shelter.

2.7.3.2 Each stack Analyser shall be connected to the ADSU through serial link in multi drop configuration. The serial link shall be MODBUS RTU protocol. Necessary hardware required at analyser side for protocol conversion shall be provided by vendor.

2.7.3.3 In addition to the analyser serial link, the above shall also accept all alarms from shelter equipments/items such as Detector alarms, power failure alarm, purge failure alarm etc.

2.7.3.4 Any alarm inputs from analyser sample handling system and calibration commands etc. shall also be provided at ADSU.

2.7.3.5 The ADSU data acquisition system shall be connected to shelter analyser and common stack analyser system console at control room.

2.7.3.6 The ADSU system cabinet shall be a free standing cabinet and shall be located at each shelter. The construction shall be similar to analyser cabinets as per clause with minimum dimension of 600W X 600D X 2100H.

2.7.4 Shelter Analyser Console:
2.7.4.1 Shelter Analyser console located at each analyser shelter shall be provided for complete analyser measurement and diagnostic data and other shelter measurement data for monitoring, calibration and maintenance.

2.7.5 Common Stack Analyser console:

2.7.5.1 The common stack analyser system console at control room shall store the complete analysis data of analysers and present this in a predefined format. The console shall be common for one or more stack analyser system in the plant and shall receive data from each ADSU data acquisition subsystem at shelter/Analyser room. The data from each shelter/ analyser room shall be provided independently and no multi dropping at field shall be considered.

2.7.5.2 The console shall be provided with stack analyser system software and shall have the following features.

a) Display of all analysis data stack wise, component wise and exception wise.
b) Alarm display & printing.
c) Report generation as per statutory requirements such as USEPA, TUV etc.
d) Freely formatted report generation.
e) Report generation as per local pollution control board requirements
f) Data storage and data compaction facilities.
g) System alarms, display & printing.
h) Predictive maintenance packages, if any.
i) Hourly shiftly, daily, weekly, monthly reports shelter wise.
j) Command for auto calibration for each analyser.
k) System shall store the analysis data and reports upto 1 year period.

2.7.5.3 The report generation as per statutory requirements shall have the following reports as minimum.

a) Data of each analyser with sample interval of 1 sec., 1 minute.
b) Performance report, period as defined by statutory regulation authority. 30 day s, quarterly, biannual, and annual as minimum.
c) Magnitude of excess emission for each analyser.
d) Specific identification of periods of excess emissions , s tart up, s hut down or other periods, cause of malfunction and corrective action.
e) Report of malfunctions or operative maintenance of each analyser along with period.
f) Summary report in case of excess emission period less than 1 % of time of reporting period, in predefined formats.

2.7.5.4 The software provided for common stack analysers shall be certified compliance to USEPA or TUV or any other statutory regulations.

2.7.6 The consoles at shelter and at control room shall access data independently from analysers. In case of failure of one console the other console shall continue to receive data. Upon resumption of failed console, the stored data from other console shall be transferred by command.
2.7.7 Each console shall have the following minimum configuration.

a) Consoles shall be PC based, Pentium latest processor with retentive memory of 512K RAM, 80GB Hard disk with 19" TFT monitor.

b) No. of background colours and foreground colours for the monitor will be seven, as a minimum. These colours shall be used to distinguish parameters such as control, information, process and alarms etc.

c) No. of display characters is 80 character X 40 lines and No. of character type is min 96 ASCII characters with character construction of 5X7 dots and pattern of 7X8 dots.

d) Length of tag no is nine alpha numeric characters.

e) Length of description is fifteen alpha numeric characters.

f) Monitor data display update rate shall not be more than two (2) seconds.

g) Dynamic graphics shall be provided with control.

h) Windowing facility is required with 4 No. of windows/Display.

i) Zooming facility is required.

j) The real time clock of each operator console shall be crystal controlled one which shall be independent of line frequency.

k) A minimum of two cursor control devices must be available with monitor of console. For example cursor control could be used for monitoring the data and engineering of the complete system.

l) Key board shall preferably be touch sensitive membrane type. Each key board entry shall be registered with an audio beep. However, if press type keyboard is provided it shall be ensured that the key board is not susceptible to dust and moisture.

m) The self diagnostic message for a subsystem failure shall appear on the anal yser console irrespective of display selected. The choice of the detailed self diagnostic displays shall be made by a key lock switch.

n) The offered printer shall be HP laser jet colour printer.

2.7.8 The communication between ADSU at analyser shelter and the common stack analyser console at control room shall be through fibre optic cable with necessary converters and the same shall be provided by vendor.

2.7.8.1 All fiber optical cables shall be routed through hard HDPE conduits and shall be totally
enclosed within using HDPE matching fittings. The HDPE conduits shall be as per IS-4984 or equivalent IEC standard. The outer Colour of the conduit shall be orange with black fittings throughout the run. Individual fiber optic cable shall have minimum one pair of spare fiber. All fiber optical cables shall be rodent resistant and armored type only.

3.0 NAMEPLATE

3.1 Each analyser and its accessory shall have a stainless steel nameplate firmly attached to it at a visible place, furnishing the following information as applicable:

a) Tag number as per purchaser’s data sheets.

b) Manufacturer’s serial number and model number.

c) Manufacturer’s name/trade mark.

d) Component being analysed and its range.

e) Area classification in which the equipment can be used.

f) Power supply requirements.

g) Analyser Outputs

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at the vendor's works in line with the inspection test plan for process stream analysers. Vendor shall provide necessary facilities, utilities, competent manpower and consumables required for carrying out the inspection.

4.2 Vendor shall submit the following test certificates and test reports for purchaser's review for each of the analyser:

a) Dimensional verification certificate for each analyser.

b) Material test report as per clause 2.2 of EN10204 for all wetted parts.

c) Manufacturer’s test reports as per clause 3.1B of EN 10204 for various bought out components.

d) Leak test report for complete analyser system including sample handling system using Nitrogen or instrument air at 1.5 times the maximum working pressure.

e) Calibration report for each analyser as per clause 4.3 of this specification.

f) Repeatability test for each analyser as per clause 4.4 of this specification.

g) Power supply variation check.

h) Test certificates for zero, span, carrier and fuel gases as applicable.

i) Certificates from statutory body for flameproof/intrinsic safety and weatherproof enclosures as applicable.

4.3 Analyser Calibration
4.3.1 Analyser along with sample handling system shall be calibrated using zero and span calibration gas samples in the following sequence:

a) Check/adjust zero by connecting zero gas and span by connecting span gas.

b) Check again zero by connecting zero gas after (a) above. Also repeat span gas check.

c) If either or both zero and span are adjusted in step (b), repeat (b) again to verify the calibration until no further adjustments are made in zero and span.

4.4 Repeatability Testing

4.4.1 Repeatability of the analyser shall be checked by connecting either span gas (if it is approximately 70% of analyser span) or any other gas sample on continuous basis for the following time period.

a) 24 hours by manufacturer and report to be submitted for review.

b) 8 hours during witness inspection.

4.5 Witness Inspection

4.5.1 All the analysers shall be offered for pre-dispatch inspection by the purchaser at vendor works. Following tests/checks shall be carried out on each analyser as a minimum:

a) Physical dimensional verification and workmanship.

b) Bill of material check for each analyser system including sample handling system.

c) Leakage testing of complete system using nitrogen or instrument air.

d) Calibration check as per clause 4.3 above.

e) Repeatability check as per clause 4.4.

f) Power supply variation check. Analyser must function satisfactorily on specified variation of power supply voltage.

g) Review of all test certificates and test reports indicated in clause 4.2 above.

4.5.2 In the event when the witness inspection is not carried out by purchaser, the tests shall any way be completed by the vendor and documents for same shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 All threaded and flanged openings shall be suitably covered to prevent entry of foreign material.

5.2 Each major part shall be sealed in thick plastic bag. Suitable moisture absorbent shall be provided for electronic components.

6.0 REJECTION
6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents, which are specifically indicated in the material requisition.

6.2 Any offer not conforming to the above requirements, shall be summarily rejected.
STANDARD SPECIFICATION

FOR

ANALYSER SYSTEM
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1.0 GENERAL

1.1 This specification defines the minimum requirements of Analyser System/systems designed for
reliable and effective analysis of various process streams.

1.2 All analysers along with their associated equipments shall be installed by the vendor inside the
analyser shelter.

1.3 All analyser shelter shall be ventilated, pressurized and air-conditioned. However, all analysers
and other associated equipments shall be so designed and selected that these will continue to
operate even in case of ventilation/pressurization failure.

1.4 Vendor shall provide all installation material including consumables to install the analysers,
sample conditioning systems, sample transfer lines, vent lines and all other accessories. All
instruments shall be completely accessible to permit adjustments, calibration and maintenance.

1.5 The components to be furnished for each sample system will depend upon the sample stream
conditions. The vendor shall select and provide all the necessary components for each of these
systems accordingly.

2.0 SAMPLE HANDLING SYSTEM

2.1 The sampling system shall consist of necessary components, including sample probes, sample
filters, pressure reducers, safety relief valves, pressure and temperature gauges, moisture
separators, flow regulators, flow meters, isolation valves etc. necessary to prepare the sample for
proper analysis.

2.2 All components shall be sized and coupled so as to keep the sample volume to a minimum.

2.3 Calibration zero and span gas connections shall be provided for each analyser.

2.4 The sampling system shall have various sub-assemblies as required. The minimum requirements
of each sub-assembly shall be as given below.

2.5 Sample Probe Assembly

a) Sampling probe shall be designed to extract true representative sample from the process
line. The design shall prevent particulates from entering into the sample system.

b) The design of probe assembly shall facilitate on line removal of the probe without
shutting off the process. Suitable mounting adapters shall be provided with the probe.

c) Probes shall be of Inconel 600 material unless specified otherwise.

d) The length of tubing between the sample probe and the sample stream pressure
reducing station shall be kept minimum by close coupling various components in between
2.6. Sample Stream Pressure reducing stations:

a) Vendor shall design and provide sample stream pressure reducing stations to minimize sample transfer time maintaining the integrity of the sample. Sample stream pressure reducing stations shall consist of pressure regulators, relief valves, pressure gauges, temperature gauges etc as required.

b) These stations will be located at the sample process connection to minimize transport time lag from the sample point to the analyser.

2.7. Sample Transfer Line

a) The sample transfer line shall transport the fluid sample from the sample stream pressure reducing stations to sample conditioning system located at the analyser shelter.

b) Vendor shall provide heat tracing for sample line wherever necessary, in order to maintain the sample integrity.

c) The routing of sample transfer lines shall be done in such a way that the total length between the sampling point and the analyser sample conditioning system is minimum. Short radius bends shall be avoided to avoid excessive pressure drop.

2.8. Sample Conditioning System:

a) Sample conditioning system shall be provided by the vendor at the analyser house/shelter.

b) Multi-stream analyser system shall have a separate sample handling sub assembly for each stream.

c) Sample conditioning system shall include, but not limited to, moisture separators, filters, rotameters, pressure gauges, flow switches, solenoid valves etc. as necessary for proper analysis of each sample stream. Isolating valves shall be provided as required.

d) Stream selecting valves shall be located as close as possible to the analyser to minimize connecting tubing length and to minimize the possibility of cross contamination of samples.

e) Stream selecting valves shall be double block and bleed and shall fail closed so as to block the sample from the analyser on loss of motive power.

f) Block valves shall be provided on all process sample lines.

g) Rotameters for measuring all sample flows shall be included.

h) Special precautions may be necessary where catalyst fines and coking material, and other difficult stream conditions are present.

i) Wherever it is necessary to maintain the handling system at elevated temperature to properly condition the sample, it shall be enclosed in a ther mally insulated,
thermostatically controller heated enclosure. Enclosure heating shall be with steam heater unless specified otherwise. Sample stream flow adjustments and analyser shutoff valves shall be operable from the front of the enclosure without opening the enclosure door. Sample stream flow, pressure and temperature indication shall be visible from the front of the enclosure.

j) Sample tubing between the sample conditioning system and the analyser shall be kept as short as possible.

2.9. Sample Stream Bypass/Fast loop:
   a) Sample stream bypass/fast loop shall be provided for the sample streams to meet the required sample transport time.
   b) Flow meters shall be provided by vendor for sample bypass/fast loop flow.

2.10. Analyser Vent:
   a) Analysers shall be vented to atmosphere individually or through a common vent system.
   b) In case common vent header is provided, the pipe diameter shall be big enough to prevent build up of back pressure.
   c) The venting of the analyser shall be done to atmosphere at a minimum height of 3 meters above the highest walkway of the structure over the analyser shelter away from any working area or any ventilation system.
   d) The vent lines or header shall be provided with low point drains.

3.0 PIPING AND TUBING:

3.1. All tubing runs shall be either horizontal or vertical, with 90° tubing bends of stainless steel tubing. The tubing shall be run and arranged such that quick visual tracing is possible. All valves, gauges and flowmeters must be visible and accessible.

3.2. Sample and vent tubing, piping, fittings, valves, traps, rotameters and other components shall be of SS 316 material, unless otherwise specified.

3.3. All tube fitting used shall be of SS 316 and shall be non-flare type of Swagelok/Parker/Hamlet make.

3.4. Sample tubing from the field shall terminate at a bulk head union plate using tube to tube bulk head fittings located at the top of the cabinet, in case sample conditioning system is enclosed in a cabinet.

3.5. Sampling line shall be arranged to be free draining without any pockets.
3.6. Vendor shall provide suitable connections for periodic flushing of sample tubing, with Nitrogen and steam, between sampling point and analyser inlet filter. Flushing connections shall be provided at both ends of each sample line.

4.0 ANALYSER

4.1 The analyser shall be furnished with all the necessary equipment to properly analyse the sample.

4.2 Material of construction for the components in contact with the sample stream shall be SS 316 except where the stream composition requires other material.

4.3 The detector cells shall be of a type that will provide adequate separation of components, minimize analysis time, minimize maintenance time and meet the performance requirements of this specification.

4.4 The analyser system temperature shall be controlled by an accurate electric heating system to ensure the proper sample separation and minimize the analysis time.

4.5 A shutdown switch shall be provided to protect the analyser from the loss of carrier gas or loss of fuel gas.

4.6 Solenoid operated multi function valves for sample inlet and column switching shall be provided.

5.0 PROGRAMMER/CONTROLLER

5.1. The programmer / controller shall be microprocessor based and shall be furnished with all the equipments necessary to properly control the analysis cycle, the automatic zero adjustment circuit, the calibration of the analyser and programmer systems and the transition of data to a DCS or digital computer and any require peripheral equipment.

5.2. Visual readout using a digital indicator shall be provided to identify each component being analysed and each step in the program as well as displaying the latest readings.

5.3. Peak peaker and long term memory circuit boards shall be provided for each component of the interest.

5.4. All program data tables shall be capable of field modification without user knowledge of higher level programming. A key lock switch or field alterable password shall be provided to limit access to system software by unauthorized personnel.

5.5. The application program in the analyser shall be retained for a minimum of six months with out external power by the use of EEPROM or Battery back-up. An EEPROM programme cartridge interface shall be provided for program loading.

5.6. Maintenance diagnostics shall be included in the software system to allow rapid trouble shooting in the event of system mal-function. Alarms in the English language shall be provided to notify the operator in the event of the mal-function. A low carrier flow alarm shall be included.

5.7. The stream number shall be printed-out on each analysis report.
6.0 ELECTRIC WIRING - SIGNAL CONTROL AND POWER:

6.1. Vendor's scope of supply and work shall include all cabling and wiring inside the analyser shelter.

6.2. Vendor shall provide an explosion proof (Exd) power distribution box for power supply to various analysers. This box shall be certified by a statutory body for use in specified hazardous area. The box shall have copper bus bars for distribution of power supply to various consumers.

6.3. Power supply to individual consumer shall be by dual pole, dual element circuit breakers. These circuit breakers shall be in explosion proof (Exd) construction certified by a statutory body for use in hazardous area and shall be mounted near the equipment served and shall have engraved plastic tag plates.

6.4. All cabling and wiring shall conform to API-RP-550. Signal and power cabling/wiring shall be segregated and run in separate raceways with separation distances as recommended per API-RP-550.

6.5. All cables shall be armoured, flame retardant PVC insulated, 600 Volt grade, stranded copper conductor. Signal cables shall be twisted pair shielded.

6.6. Conductor size for power cables shall be 2.5 sq. mm (min.) and for signal cables it shall be 1.5 sq. mm.

6.7. Colour coding for power supply wiring shall be red for phase, black for neutral and green for earth.

6.8. Vendor shall provide junction boxes for signal and control cables separately which shall serve as interfaces for cables going to remote control room. These junction boxes shall be explosion proof (Exd) certified by statutory body for use in specified hazardous area.

6.9. Wire termination shall be done using self insulating crimping lugs.

6.10. All cables, wires shall be provided with identification ferrule (one piece ferrule/ cylindrical ferrules_ for proper identification.

6.11. Terminal strips shall be provided with identifying terminal numbers, as required. Terminals shall be screw less clamp type.

6.12. 20% spare terminals, cable entries with cable glands, relays and other components wired up to terminals shall be provided.

7.0 COMPRESSED GAS CYLINDERS AND THEIR HANDLING:

7.1. Each analyser shall be provided with the following compressed gas steel cylinders.

a) Carrier gas and fuel gas (wherever required) with dual manifold cylinders configuration.

b) Calibration gas sample bottles.
7.2. Fuel gas and Carrier gas cylinders and associated manifolds shall be located on a concrete pad outside the analyser building. The gas cylinder manifold shall be arranged so that one cylinder may be replaced while the analyser remains in operation on the other cylinder. Cylinders shall be sized 1A (225mm diameter x 1300mm long) and shall be supplied with auxiliaries such as fittings and two stage regulators.

7.3. Calibration gas cylinders shall be located outside the analyser shelter. Vendor shall include a drawing showing the layout of cylinders.

7.4. Racks shall be provided to support cylinders, piping, valves and pressure regulators associated with high pressure gas cylinder manifold system. Each cylinder in the system shall be secured to the rack by a separate chain or clamp.

7.5. A pressure relief valve, vented to a safe location outside the building shall be installed on the low pressure side of the pressure reducing regulator of each cylinder. Vent piping shall be installed in a manner to prevent the entry of bugs or moisture into the outlet of the vent. This vent shall be in addition to the analyser vent.

7.6. All pressure regulators shall be two stage type. A sign identifying the type of gas applied to a manifold shall be placed above each cylinder rack.

7.7. The location and separation of hydrogen manifold from other flammable gas manifolds shall be in accordance with NFPA 50A-1973 section 52 and 61.

7.8. All tubing between the cylinders to the analysers shall be complete and easily removable from each and either end.

7.9. Vendor's quote shall include fuel, carrier and calibration gas cylinders as necessary, as a minimum, for:

i) The field testing, commissioning and final acceptance

ii) Six months from the date of acceptance.

7.10. The calibration gases shall be of high purity, at least better than the specified accuracy and precision values for analysers. It is preferable to prepare calibration gases by Gravimetric method.

7.11. The concentration of calibration gases must remain constant for a period of at least one year.

7.12. The material of construction of cylinders shall be suitable for maintaining stability of the calibration gas mixture for the specified time. Vendor may quote for staggered deliveries wherever calibration mixture is not stable.

7.13. The vendor must submit the following certificates from any recognised certifying agency/laboratory;

i) Accuracy/Precision of the calibration gas.
ii) Stability of sample for at least one year.

7.14. Vendor shall forward all the details including the source of supply, certifying agency, cylinder size and volume, sample pressure, dew point, regulator type and make etc.

In addition, vendor must furnish calculations for number of cylinders quoted of each type. For calibration gas cylinders, consider calibration frequency as once in every fortnight.

8.0 SAFETY REQUIREMENTS:

8.1. Hazardous Area Protection:

a) The analyser shelter shall be in hazardous classified area. Positive pressure and ventilation from a clean air source shall be provided to achieve this classification.

b) It is intended to operate the analysers even during the ventilation failure, hence it required that all analysers shall be suitable for hazardous area.

c) All the electrical fittings provided in the analyser shelter shall be explosion proof type. However, a safety system shall be provided by the vendor to switch off power supply to all electrical equipments and accessories not suitable for hazardous area in case of ventilation failure. To do this it shall be ensured that all analysers continue to work safely even under these conditions.

d) All junction boxes, power distribution cabinets, LEL detectors and their panel and other safety devices shall be suitable for the hazardous area certified by a statutory body.

8.2. Grounding:

a) All electrical equipment in the analyser shelter and outside shall be grounded properly.

b) Cylinder racks, sample conditioning enclosures, analyser racks, shall also be grounded directly to the AC ground bus.

c) All necessary grounding bus requirement for Equipment grounding and signal shields shall be provided by the vendor in the analyser shelter. Vendor shall also provide all earthing arrangements inside the analyser shelter.

8.3. Combustible Gas Detection System (LEL Detectors):

a) Vendor's scope includes of supply and installation of combustible gas detectors with associated monitoring system for the analyser shelter.

b) Combustible gas detectors shall monitor all inlet air intake points. The detectors shall be calibrated to give alarm and high alarm at 20% and 40% respectively of the LEL of the component with the lowest LEL in the area. On the occurrence of high alarm the ventilation system shall be shut-off. Vendor shall provide potential free DPDT contacts rated at 230 VAC 5 Amp for connection to ventilation system.
c) Shutoff of ventilation system shall be based on 2 out of 3 voting, which means that only if two detectors out of the three provided indicate a high LEL, trip shall provided.

d) Additionally, combustible gas detectors shall monitor the analyser house/shelter interior and exhaust air. These detectors shall give alarm and high alarm as mentioned above, however no shutoff of ventilation system shall be required.

e) Vendor shall calculate total requirement of combustible gas detectors along with their location.

f) The monitors for LEL detectors shall be provided with malfunction, warning and danger lights and 0 to 100% indicator.

g) Vendor shall provide grouped high alarm and high - high alarm SPDT contacts rated for 230 V AC 5 Amp for repeat alarms in remote control room.

h) The monitors for LEL detection system shall be installed in a panel which shall be pressurized as per NFPA 496 type `X' purge.

8.4. Fire/Smoke detection

a) Vendor’s scope shall include supply and integration of fire detectors/smoke detectors (ionisation type) within the analyser shelter. The no. of shelters shall be decided by the vendor based on the shelter size and coverage of area within the shelter.

b) The monitors for the fire detection shall be installed in a pressurised/ purged panel as per NFPA 496 type X purge. This may be shared with LEL monitor panel.

c) The signals from the fire system monitor shall be provided for:

- One contact for alarm on the warning panel.
- One contact each for repeat alarm in the control room DCS and fire panel of Electrical section.

8.5. Oxygen gas monitoring

a) Vendor shall provide a maximum of two nos. of oxygen gas monitoring system for sensing deficiency of oxygen within the shelter.

b) In case the monitors show low concentration of oxygen within the analyser shelter, an alarm shall be initiated on the warning panel. The repeat alarm shall also be provided for DCS in the Main control room.

c) Oxygen monitors should be located in purged panel as per NFPA 496 type X purge. These may be located in the same panel where LEL detectors are installed.

8.6. Warning Panels:
a) Vendor shall provide warning panels for audio visual alarming of hazardous conditions inside the analyser shelter. One such panel shall be installed by vendor on each of the external walls of the analyser shelter where entrance doors are provided.

b) The warning panel shall provide the following audio - visual alarms:
   
   i) Presence of combustible gases inside the analyser shelter.
   ii) Loss of analyser shelter pressurisation
   iii) Ventilation system failure
   iv) Fire/smoke within the shelter
   v) Oxygen deficient within the shelter

c) For alarming of analyser shelter pressurisation failure vendor shall provide an explosion proof pressure switch for sensing analyser shelter inside pressure.

d) These warning panels shall be of explosion proof (Exd) construction certified by a statutory body for use in hazardous area.

8.7 Minimum two no beacon assembly and 1 no. hooter suitable for specified hazardous area shall be provided on the shelter to warn the operator of presence of hazardous area inside the shelter.

9.0 FACTORY TESTING AND ACCEPTANCE:

9.1. The analyser systems shall be thoroughly checked and tested prior to shipment to assure correct design, construction and proper operation.

9.2. The Owner/Consultant reserves the right to be involved and satisfy himself at each and every stage of inspection and testing.

9.3. During the final testing vendor shall test and demonstrate to the Owner/Consultant, the functional integrity of all analysers, sampling systems and all other hardware. Repeatability test shall be performed on all analysers for a test period of 24 hours. No material or equipment shall be transported until all required tests are successfully completed and certified `Ready for shipment' by the Purchaser/Consultant. Software’s, if involved, shall also be tested.

9.4. Vendor shall submit schedule of factory testing and inspection.

9.5. After placement of order vendor shall submit his factory testing and customer acceptance procedure for Purchaser / Consultant approval. This document shall contain the information related to each test e.g. purpose of test, definition, test procedure, results expected and acceptance.

9.6. Purchaser / Consultant has every right to add or delete any test in vendor's test procedure and acceptance criteria. The system shall be tested and accepted as per the approved testing procedures and acceptance criteria. The cost of performing all tests shall be borne by the vendor.

9.7. Vendor shall notify the Purchaser / Consultant at least three weeks prior to final system testing at vendor's works. In the event that representatives of Purchaser / Consultant arrive and the system
is not ready for testing, the vendor shall be liable for back charging for any extra time and expenses incurred by the Owner.

9.8. It shall be vendor's responsibility to modify and/or replace any hardware, equipment or analyser if the specified functions are not completely achieved satisfactorily during factory testing and acceptance.

10.0 INSTALLATION, TESTING AND COMMISSIONING:

10.1. Vendor shall provide the services of his installation team which would install the equipment in the analyser shelter and in the field, lay the tubing from sample probe to analyser shelter, lay the interconnecting cabling tubing inside the analyser shelter, perform system checkouts, test and commission the entire system.

10.2. All technical personnel assigned to the site by the vendor shall be fully conversant with the system supplied and shall have capability to bring the system on-line quickly and efficiently with a minimum of interference with other concurrent construction and commissioning activities.

10.3. Vendor's responsibility at site shall include all activities necessary to be performed to complete the job including;

a) Receipt of all analysers and related hardware, and checking of completeness of supply. In case of shelters, verification of all analysers and accessories duly installed tubed and wired

b) Installation of all analysers, and other associated equipment including all safety equipment like LEL detectors, annunciators, panels etc., all auxiliaries like power supply distribution boxes, all interconnecting tubing/piping etc. so as to complete the job in case of analyser shelter.

c) Installation of sample probes, pressure reducing stations, sample conditioning systems, interconnecting tubing, heat tracing etc.

d) All analyser sample stream bypass, vent and drain tubing/piping.

e) Termination of all field cables or cables to control room, ferruling/ tagging of interconnecting cables in analyser shelter.

f) Interconnection cabling inside the analyser shelter

g) All civil works like grouting, fixing etc and patch up work where vendor is likely to remove the plaster and shall make holes in the walls, floor or ceiling.

h) Checking of interconnections, hardware configuration, overall system functioning.

i) Leakage rate test.

j) Liaison with vendor's home office.
k) Field testing.
l) Commissioning of the complete analyser system.
m) Final acceptance testing.

10.4. System Check-outs:

a) Checking of all interconnections, configuration and overall system functioning.
b) Any discrepancy found during checking shall be brought to the notice of Engineer-in-Charge.
c) All the check-outs shall be performed in the presence of Owner/PMC authorised representative. All headings shall be recorded on a suitable format and shall be submitted for approval.
d) After system checking is completed, vendor shall connect back any terminal or tubing or connection removed for loop checking.
e) All the equipment shall be checked thoroughly after its receipt at site. The tests, as a minimum, shall include;

i) Visual and mechanical testing
ii) Complete system configuration loading
iii) Calibration of all analysers, and other related equipment.
iv) Demonstration of all system functions.
v) Demonstration of all system diagnostics.
vi) Checking of correct change of redundant devices.
vii) Demonstration of analyser accuracies, linearities, repeatabilities, response time etc.
viii) Demonstration of proper operation of system at specified voltage supply specifications.
ix) A leakage test shall be conducted on entire system. Maximum permissible leakage rates shall not exceed 5% per hour of specified designed pressure.

11.0 TRAINING:

Vendor shall be responsible to train the Purchaser/Consultant personnel in the field for maintenance of hardware and software. The outline of each course including the course contents and the duration shall be forwarded by the vendor along with the offer.

12.0 DOCUMENTATION:
Vendor shall furnish all the manuals, including for maintenance and operation, necessary to test, operate and maintain etc the analysers and other related equipment, hardware and software.

13.0 ENGINEERING DRAWINGS:

13.1. Vendor shall provide a complete set of drawings covering each part of supply for Purchaser/Consultant record. The vendor is required to include Purchaser's project number on each of his drawing.

13.2. All field modifications shall be carefully recorded by the vendor's installation and commissioning personnel and changes shall be incorporated into the final drawings.

14.0 FINAL ACCEPTANCE TEST:

The Owner will take over the system from the vendor after the final acceptance test, which is defined as successful uninterrupted operation of the integrated system for three weeks with desired accuracy and repeatability. Vendor's personnel shall be present during the test. Any malfunctioning of the system components shall be replaced/repair as required. Once the system failure is detected, the acceptance test shall start all over again from the beginning.

15.0 TESTING AND CALIBRATION EQUIPMENT:

Vendor shall make available all consumables including calibration gas cylinders, instruments and equipments necessary for testing, calibration, maintenance etc. as defined by the 'scope of work'. All instruments and equipments used for the above purpose shall be of standard make with accuracy better than the accuracy expected from the calibrated/tested equipments and shall be certified by National Physical Laboratory or other equivalent agencies.

16.0 SPARE PARTS:

Vendor shall quote separately for spare parts required for a two year period of operation for the complete analyser system and the associated auxiliaries offered. Vendor shall enclose a list of spare parts quoted along with the offer.

17.0 MAINTENANCE CONTRACT:

Vendor shall quote separately for maintenance contract after warranty period for two years as per job requirements. The personnel deployed shall have thorough knowledge of the system and at least two years of experience as maintenance of similar system.

18.0 PACKING AND SHIPPING INSTRUCTIONS:

18.1. All materials used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be of recognised brands and shall conform to the best standards in the areas for the articles which are being packaged.
18.2. Workmanship shall be in accordance with best commercial practice with the requirement of applicable specifications. There shall be no defects; imperfections or omissions which would tend to impair the protection of the package as a whole.

18.3. The package shall be suitable for storing in tropicalised climate as per specified ambient conditions.

18.4. Shipment shall be thoroughly checked for completeness before final packing and shipment. Vendor shall be fully responsible for any delay in installation or commissioning schedule because of incomplete supply of equipment.
STANDARD SPECIFICATION

FOR

PROCESS STREAM ANALYSE
CONTENTS

1.0 GENERAL

2.0 DESIGN AND CONSTRUCTION

3.0 NAME PLATE

4.0 INSPECTION AND TESTING

5.0 SHIPPING

6.0 REJECTION
1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the data sheets, covers the requirements for the complete design, materials, nameplate marking, inspection, testing and shipping of process stream analysers. This standard specification shall be applicable for all types of process stream analysers irrespective of whether separate specifications are included or not included in this specification.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry:

ANSI/ASME American National Standards Institute! American Society of Mechanical Engineers.

B 1.20.1 Pipe Threads. General Purpose (Inch)

B 16.5 Steel Pipe Flanges and Flanged Fittings. NPS 1'2 through NPS24.

B 16.20 Metallic Gaskets for Pipe Fittings, Ring Joints, Spiral wound and Gasketed.

API American Petroleum Institute

Manual on Installation of Refining Instruments and Control System

RP 551 Process Measurement Instrumentation

RP 552 Transmission System

RP 554 Process Instrumentation and Control

RP 555 Process Analysers

ASTM693 Standard Practice for cleaning methods and cleanliness levels for material and equipment used in oxygen-enriched environment.


EN 50020 Electrical Apparatus for potentially explosive atmospheres-Intrinsic safety 'i'

EN 10204 Inspection Documents for Metallic Products.

IEC-60079 Electrical Apparatus for Explosive Gas Atmosphere.

IEC-60529 Degree of Protection Provided by Enclosures. (IP Code)


IS-13947 Specification for Low Voltage Switchgear and Control gears.

IS-2148 Electrical Apparatus for Explosive Gas Atmosphere-Flameproof enclosures ‘d’.

NFPA 496 National Fire Protection Association

1.1.3 In the event of any conflict between this standard specification, job specification/data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations

b) Data Sheets

c) Standard Specification

d) Codes and Standards

1.1.4 In addition to meeting the purchaser’s specification in totality, vendor’s extent of responsibility shall include the following:

a) Purchaser’s data sheet indicates the type of analyser and the minimum sample conditioning system requirements. Vendor shall be responsible for the selection of proper analyser and design of the sample conditioning system to analyse the component/components of interest within the stated performance requirements.

b) Carry out complete application engineering of the process gas analyser so as to achieve the desired analysis within stated performance requirements.

c) Provide all hardware and software, as necessary, to meet the functional requirements specified in the purchaser's specifications.

d) Provide complete data to purchaser for successfully proving serial communication with purchaser’s host system i.e. DCS when specified in the job specification.

e) Purchaser’s data sheets indicate the minimum requirements of material of construction for the analyser and its sample conditioning system. Alternate superior material of construction shall also be acceptable provided vendor assumes complete responsibility for all the parts of the analyser system so as to be compatible with the process stream and surrounding atmosphere as specified in purchaser's data sheet.

1.2 Bids

1.2.1 Vendor’s quotation shall be strictly as per the bidding instruction to vendor attached with the material requisition.

1.2.2 Whenever a detailed technical offer IS required, vendor’s quotation shall include the following:

a) Compliance to the specifications.
b) A detailed specification sheet for each analyser, which shall provide information regarding type, materials of construction, performance specification and accessories of analyser. The material specification and units of measurement for various parts in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheets. All the relevant terminology used in purchaser's data sheets and standard specifications shall be as per ISA RP 31.1.

c) A detailed drawing showing various components of sample conditioning system and piping/tubing hook-up arrangement including sample return, vent, utilities in connection and requirement of heat tracing (i.e. electrical or steam tracing), as necessary.

d) Sample transportation time calculations for the specified distance between sample point and analyser indicating sample flow rate and the recommended size of the sampling tube.

e) Calibration gas cylinder calculations considering six months of continuous operation with once a week calibration. The calculation sheet shall indicate the rate of gas consumption and specification of gases including composition, concentration, accuracy and shelf life of calibration blend.

f) References gas cylinder calculations considering six months of continuous operation. The calculation sheet shall indicate the rate of gas consumption and specifications of the reference gas.

g) Proven references for each offered model inline with clause 1.2.3 of this specification.

h) A copy of approval for intrinsically safe/flameproof enclosure, whenever specified, from local statutory authority, as applicable, such as Petroleum and Explosives Safety Organisation/Chief Controller of Explosives (CCE), Nagpur or Director general of Mines Safety (DGMS) in India, along with:

i) Test certificate from recognised house CMRI/ERTL etc. for flameproof enclosure as per relevant Indian Standard for all Indian manufactured equipments.

ii) Certificate of conformity from agencies like CSA, BASEEFA, PTB, LCIE, FM, UL etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

i) Utility requirements and their consumption i.e. instrument air, cooling water, steam etc. along with their process conditions like flow, pressure and temperature.

j) Power consumption for each analyser and its accessories.

k) HVAC requirements i.e. heat load, humidity particulate/chemical filtration etc.

l) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason, they must include a list of deviations tag number wise, summing up all the deviations from the purchaser's data sheets and other technical specifications along with the technical reasons for each of these deviations.

m) Catalogues giving detailed technical specifications, model decoding details and other related information for each type of analyser and accessories covered in the bid.
1.2.3 All items, as offered, shall be field proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date for the similar analysis as specified in the purchaser's data sheet. Items with proto-type design or items not meeting provenness criteria specified above shall not be offered.

1.2.4 Whenever specified, vendor must furnish certified values of failure rates, probability of failure on demand and test interval for the safety integrity level analysis.

1.2.5 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals, etc shall be in English language only.

1.2.6 Vendor shall also quote for the following: -

a) Complete calibration kit consisting of calibration gas cylinders, pressure regulators, gauges, cylinder gas piping manifolds and driers, (as required) etc. as a minimum, for each analyser. In case of dual range analyser, separate calibration standards shall be provided for each range. For the purpose of calculating requirement of zero and span calibration samples/gases, consider calibration time of 30 minutes every week for each analyser for a period of six (6) months of continuous operation.

b) Complete reference gas kit consisting of Reference gas cylinders, pressure regulators, gauges, cylinder gas piping manifold and drier etc as a minimum separately for each analyser as applicable. The reference gas cylinders shall be supplied for a period of six (6) months of continuous operation.

c) Consumable spares for the duration of six months with list of items as per vendor recommendations for each analyser system, unless otherwise specified in job specification.

d) Start up and commissioning spare parts for each analyser/analyser system as per vendor recommendations. However this list of spare parts must include 5% or minimum one of each type of following spare parts:

- Solenoid valve
- Pressure regulator
- Filters
- Temperature controller
- IRIUV Source (lamp)
- Peristaltic pump
- Set of fuses
- Set of o-rings
- Tubing and tube fittings (sizes smaller than 6 mm or y”).

Additional spare parts, if required, during start-up and commissioning, even though not listed in the list of start-up and commissioning spares, shall be supplied by the vendor without any implication.
e) Any special instrument or tool needed for testing, calibration and maintenance of the analyser such as spanner set (for tubes smaller than 6 mm or 1/4”), non-magnetic tools, bubble rotameter etc.

f) Training at vendor works and at site as specified in job specifications.

g) Two years operational and maintenance spares for each analyser and its accessories as per vendor recommendations, which shall include spare parts like electronic modules, temperature controller, power supply module, flow meter, solenoid valve, pressure regulator, local indicator, tubes, fan assembly, sample cell, detector assembly, UV/IR source/lamps, set of o-rings, set of fuses etc.

1.3 Drawing and Data

1.3.1 Detailed drawing, data, catalogues and manuals required from the vendor are indicated by the purchaser in the vendor data requirement sheet attached with the enquiry. The required number of reproducible, prints, and soft copies shall be despatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data, installation, operation and maintenance manual etc., submitted by the vendor after placement of purchase order shall include the following, as a minimum;

a) Specification sheet for each analyser and its accessories.

b) Certified drawings for each analyser and its accessories, tag number wise, which shall provide the following information:

i) Overall dimensions in millimetres.

ii) Sampling system details identifying each component with make and model number, process connection, utility connection, calibration sample/gas connection, heat tracing requirements, sample vent and fast loop details etc.

The flow, pressure and temperature at interface and other appropriate location must be shown in the sampling system drawing.

iii) Detailed interconnection drawing of each analyser identifying each component with terminal number, cable type, cable size and cable entry details. The interface details shall be clearly identified in the drawing.

iv) Grounding details.
v) Power supply distribution details.

c) Programming/configuration data for each analyser, as applicable.

d) Serial interface specification including its configurational data (addresses) for host communication.

e) Power consumptions and utility requirements.

f) Calibration curves and calibration data for each analyser.

g) Zero and span calibration gas specification including composition, shelf life time and accuracy.

h) Copy of type test certificates.

i) Copy of the test certificates of all the tests indicated in clause 4.0 of this specification

j) Installation procedure for each analyser and their accessories.

k) Calibration and maintenance procedures including replacement of its parts/internals wherever applicable.

1.4 Definitions

1.4.1 The following definitions shall apply for analysers and their accessories:

a) Transportation time

Transportation time is the time interval between a step change in the process fluid composition in the process line and the initial analyser response (excluding analyser response time).

b) ResponseTime

The time interval between the initial response of the analyser and the time required for the analyser output to reach a value of 90% of the final output value for a step change in sample quality.

c) Time Constant

The analyser response to reach a value of 63% of the final output value for a step change in sample quality is called the analyser time constant.

d) Repeatability

Repeatability of a measurement is the band of values within which an analyser repeats its measurement when the same sample is applied to it. The short term repeatability is generally determined by multiple readings of a sample during calibration and is usually true random error over short period of time if external influences like pressure and temperature etc remain constant.
It is also defined as the difference between two successive analyser results that would be exceeded in the long run in only one (1) case in twenty (20) when a single analyser system is operated on a flowing sample of uniform quality.

e) Sensitivity

The sensitivity of an analyser is a measure of an analyser's ability to detect a least change in concentration of a measured component that is not masked by the background noise.

f) Accuracy

Accuracy of a measurement is the measure of how close the measured value is to the true value of the sample. For all type of analysers, accuracy is primarily a function of the accuracy of the standards used for calibration.

g) Analyser Rack

An open analyser mounting structure with/without canopy used for mounting analysers, sample handling system and their accessories individually or together in combination.

h) Analyser Cabinet

Small housing in which analysers are installed individually or grouped together. Maintenance is performed from outside the cabinet with door(s) open.

2.0 DESIGN AND CONSTRUCTION

2.1 Analyser Requirements

2.1.1 The type of analyser and its measuring principle is specified in the purchaser's data sheet. Accessories and equipments as required to make online analysis complete are also specified in the data sheet. In general, the scope shall include the following:

a) Sample probe and sampling system, as applicable

b) Analyser complete with all hardware and software consisting of detector, transmitter and associated equipments.

c) Fast loop and Sample return system, as applicable

d) Calibration and maintenance equipment.

e) Gas cylinders for zero and span calibration.

Unless otherwise specified the scope shall also include supply of all interconnecting tubing, piping, fittings, heat tracing equipment etc., excluding sample return piping from analyser battery limit to sample return header.

In-situ analysers when specified may not include items 2.1.1(a) and (c)
2.1.2 Analysers and its related equipments directly connected to process line and In-situ analysers shall be capable of withstanding line pressure and temperature conditions specified in the purchaser's data sheet.

2.1.3 The analyser design and design of sample handling system shall be such that components or any sub-assembly that requires removal shall be possible without any need to disassemble any other component. Such components shall include items like stream selector valves, filters, pressure regulators, flow-indicator, detector, electronic modules etc.

2.1.4 Analyser shall be microprocessor based with state-of-the-art technology and shall be capable of being configured from analyser front panel locally using built-in keyboard. When specified, it shall also be possible to configure the analyser from remote through a separate terminal.

2.1.5 The configuration related data of the analyser including set range shall be stored in a nonvolatile memory such that this data remains unaffected by power fluctuations or power off condition. In case vendor's standard product stores configuration data in battery backed RAM, analyser shall have facility to provide battery drain alarm as diagnostic maintenance message.

2.1.6 The span of the analyser shall be field adjustable from the analyser front without opening the analyser enclosure. In case, separate device is required to make such a change, the same shall be included, by vendor in their scope of supply.

2.1.7 Analyser shall run diagnostic subroutines on continuous basis and shall be able to provide diagnostic alarms related to analyser optics, detector and electronics, as and when any failure/malfunction is detected.

2.1.8 Analyser shall have an integral output meter with digital readout in engineering units.

2.1.9 All interconnecting wiring shall be colour coded/numbered and terminal blocks be clearly identified.

2.1.10 The analyser shall be capable of providing the following outputs:

a) Isolated 4-20 mA DC current output for each analysed component. Smart or field bus output shall be provided when specifically indicated in the purchaser's data sheet.

b) RS485 serial output with MODBUS (RTU) protocol, whenever serial output is specifically indicated in the purchaser's data sheet. The serial output signal shall contain analyser data of component of interest and diagnostic alarms, as a minimum.

c) SPDT contact outputs for various diagnostic alarms (as applicable) such as:

i) High or low set point alarm as measurement
ii) analyser failure
iii) low sample flow
iv) temperature control failure
v) purge failure

Any other alarm contact, either specifically indicated in purchaser's data sheet or available as standard with the analyser, shall also be provided.
2.1.11 The design of analyser system shall be in compliance with the electromagnetic compatibility requirements as per IEC-61000-4-X.

2.1.12 Material of Construction

2.1.12.1 Unless otherwise specified, the material of construction of all components wetted by the sample shall be SS316, as a minimum. Vendor must ensure the compatibility of material of each component with the process fluid.

2.1.12.2 Material of all soft parts like diaphragms and o-rings shall be of PTFE. Other vendor standard materials can also be acceptable provided these are compatible with the specified process condition.

2.1.12.3 The material of construction of all non-wetted parts shall be as per manufacturer's standard. However non-metallic materials for casings, enclosures and instrument covers shall be avoided.

2.1.13 Power Supply

2.1.13.1 Unless indicated otherwise, the analyser including the sample handling system shall operate at 110V 50Hz power supply.

2.1.13.2 The analyser performance shall be within the specified limits when the supply voltage varies by ±10% of specified value and supply frequency varies by ±3 Hz of specified value.

2.1.13.3 Electrical tracing when specified, shall operate at 230V 50 Hz supply. 230V 50Hz power supply shall also be used for analyser cabinet/panel lighting and air conditioning unit, when specified.

2.1.14.1 Unless otherwise specified, the following shall govern;

a) Threaded connections shall be NPT to ANSI/ASMEB 1.20.1.

b) Flanged connection shall be as per ANSI/ASME B16.5.

c) Flange face finish shall be smooth concentric to clauses 6.4.4.1, 6.4.4.2, and 6.4.4.3 of ANSI/ASMEB 16.5. The face finish shall be as follows:

\[
\begin{align*}
125AARH &: 125\text{ to }250\text{ AARH} \\
63AARH &: 32\text{ to }63\text{ AARH}
\end{align*}
\]

d) Ring type joint flanges shall have octagonal grooves as per ANSI/ASTMB16.20.

2.1.14.2 End connection of sizes 6 mm or below shall be suitably protected against damage.
2.1.14.3 All end connections shall be clearly identified by attaching labels or stainless steel plate of suitable size.

2.1.15 Enclosure Type

2.1.15.1 Analyser enclosures and related accessories shall be suitable for the electrical area classification indicated in purchaser’s data sheets. Unless otherwise specified, the enclosures shall comply to the following standards:

Weather proof housing : IP 55 as per IEC-60529 / IS-13947
Flame proof housing : Flame proofEx (d) as per IEC-60079 / IS-2148
Purged Enclosure : NFPA 496

Flameproof and purged equipment shall also be made weatherproof.

2.1.15.2 In addition to meeting weatherproof requirements specified in clause 2.1.15.1 of this specification, intrinsically safe analysers shall meet the requirements specified in EN 50020 and shall be certified for the area classification specified in the purchaser’s data sheet.

2.1.15.3 Analyser where air/nitrogen purge is provided, purge shall be as per NFPA 496 Type X. Analyser power shall cut off in case of purge failure. Purge failure alarm shall be provided for purchaser use.

2.1.15.4 Separate cable entries shall be available in the analyser/enclosure for power and signal cable. Unless otherwise specified, following shall apply:

a) Cable entry and terminal size for power cable shall be informed during detail engineering. Explosion proof 3 way junction box with cable glands shall be supplied, if required.

b) Cable entry for Serial cable/signal cables (Signal output) shall be 1/2" NPT (F).

c) Cable entry for multi-pair signal cables (Multiple output) shall be 1\1/1," NPT (F).

2.1.15.5 All enclosure entries including sample, utilities, cables etc. shall be clearly identified by attaching label or stainless steel plate of suitable size.

2.2 Sample Handling System

2.2.1 The sample handling system shall consist of primary sample conditioning near sample take off point, sample transportation line, secondary sample conditioning near the analyser, sample return, sample/analyser vent and sample drain/recouping system, as applicable. The primary sample-conditioning unit shall be a fabricated assembly and shall be mounted on a stainless steel plate suitable for surface mounting.

Secondary sample conditioning shall also be a fabricated assembly and shall be either
mounted on a stainless steel plate or within an enclosed cabinet box with a viewing window. In case the temperature is required to be maintained at primary and secondary sample conditioning, both these conditioning units shall be installed in the heated box/cabinet.

2.2.2 Process Stream sampling shall be continuous and analyser shall be located as near as possible to the sample take-off point. Where the analyser is located away from the sample take-off point, vendor shall design the sample fast loop (bypass loop) as part of sampling system. Design shall ensure that the sample drawn is true representative of the process stream to be analysed.

2.2.3 In general, sampling systems shall be designed and constructed in accordance with API-RP555. The design of sample handling system shall consider the following factors, as a minimum:

a) The pressure-temperature conditions required for the analyser.
b) Interfering components in the process sample.
c) Normal and abnormal sample compositions.
d) Sample return pressure-temperature conditions.
e) Fouling sample conditions e.g. polymer formation or presence of solids etc.
f) Transportation time requirements.
g) Utilities available and their process conditions.

2.2.4 Unless otherwise specified, material of all components wetted by sample shall be suitable for the process fluid and sample process conditions specified in the purchaser's data sheet. The material of construction for all wetted parts shall be, 316 SS, as a minimum.

2.2.5 Sampling system shall include all elements as necessitated by the process conditions indicated in the purchaser's data sheets, to make the sample suitable for the analysis. This shall include but not limited to filters (coarse and fine), pressure regulators, relief valves, flow indicators, flow controllers, temperature indicators, scrubbers, heaters, coolers, dryers, sample pumps, aspirators etc.

Each sampling system element shall be capable of being removed without disassembling the entire system.

2.2.6 Sample probe shall be provided by the vendor to obtain representative sample from the line. The sample probe shall be inserted in the pipe through a line isolation valve (ball or gate valve), which shall be part of vendor's scope of supply. The probe design shall ensure the following:

a) On-line removal and insertion of the probe with non-fly-off design

b) Unless otherwise specified, end connection for installation in the line shall be 1 1/2" flanged with type and rating as specified in purchaser's data sheet. The line isolation valve shall also be of the same size and rating as probe end connection.

c) The probe diameter shall be such that it can be easily inserted or removed through the line isolation valve when in fully open condition.

d) The length of the probe shall be selected considering its insertion upto the middle of the pipe. For the purpose of calculating probe length, consider nozzle length as 200 mm.

2.2.7 Sampling system shall include a sample block valve on all process sample line. The block valve
shall be provided meeting the following requirements:

a) The block valve shall be located immediately after the sample probe.

b) Where purchaser's data sheet do not indicate the requirement of sample probe, the block valve shall be provided in the sample line as a part of primary sample conditioning unit.

c) The size of the sample block valve shall be as per the sample line size while the rating shall be as specified in the purchaser's data sheet.

2.2.8 The size of the sample tubing shall be decided by the vendor considering:

a) The distance between sample take off and analyser specified in purchaser's data sheet.

d) The specified sample transportation time.

e) Pressure at the sample take off point.

Where no transportation time is specified in the purchaser's data sheets, vendor shall consider the sample transportation time as 60 seconds.

2.2.9 Where sample is required to be transported in hot condition, sample shall be drawn using pre-fabricated heated tubes. The heated medium shall be either steam or electric power as specified in purchaser's data sheet. Heating shall be controlled such that the sample temperature is maintained typically around +200°C above the sample dew point.

2.2.10 When fast loop is specified or recommended by vendor, vendor shall provide flow meter for sample bypass flow. Sample return line to process shall be provided with isolation valve and check valve. Vendor shall ensure that return pressure of the sample shall be higher than the pressure of the process return point specified in purchaser's data sheet.

2.2.11 Sampling system shall include provision for connecting calibration sample/gases in auto or in manual configuration as specified in purchaser's data sheet. When no specific requirement is indicated, the provision shall be made for manual configuration only.

2.2.12 In case of multi stream analyser, the sample handling system shall utilize double block and bleed configuration to prevent cross-contamination of samples. All stream selection valves shall have bubble tight shut off. The block valves shall be fail-close type while bleed valve shall be fail-open type.

2.2.13 Filters shall always be provided in dual configuration. It shall be possible to replace the filter without upsetting the operation of the analyser.

2.2.14 The sampling system shall be designed to consider plugging of sample lines under following conditions, if applicable:

a) Failure of heat tracing
b) Failure of sample pump
c) Failure of instrument air, particularly when sample dilution technique is adopted for sample.

d) Upset of short up conditions, if excessive solids/solid particles are expected under these operating conditions.

2.2.15 Unless specified otherwise, sample lines used for carrying samples for more than one analyser shall be provided with sample pumps in dual configuration. It shall be possible to remove or insert the pump without upsetting the sampling system.

2.2.16 A suitable restriction orifice shall be provided in each sample line to limit the sample flow exceeding thrice the normal flow in the event of tube rupture or opening of tube down the line.

2.2.17 Whenever auto-calibration requirement is specified in the purchaser's data sheet, it shall be possible to initiate auto calibration cycle at preset time interval defined by user either manually via the analyser keyboard or remotely through an external contact.

The sample handling system shall be designed to include all hardware and/or software to meet this requirement. The analysed component concentration output shall remain at the last good measured value during auto calibration cycle.

2.2.18 Analyser rack and cabinet

a) Whenever specified in the purchaser's data sheet, the analyser shall be supplied in pre-assembled, pre-tubed and pre-wired condition complete with sample handling system. The primary sample conditioning unit i.e. conditioning at sample tap off point shall be supplied separately.

b) When open rack mounted installation is specified in purchaser's data sheet, the analyser and sample handling system shall be supplied installed in an open rack with canopy to protect the analyser from direct sunlight and rain. The open rack shall be fabricated using channels/pipes of suitable size. The material of construction shall be stainless steel. The canopy shall also be fabricated out of SS plate of 1.2mm thick.

c) Whenever closed cubical mounted installation is specifically indicated in the purchaser's data sheets, analyser and sample handling system shall be supplied preinstalled in tree standing closed analyser cabinet:-The analyser-cabinet-shall-be suitable for outdoor installation and shall be provided with a key lock.

Cabinet shall be fabricated out of 2.0mmSS sheet reinforced with angles of suitable sizes. Fittings and hinges shall be of stainless steel. Anchor bolts required for installation of cabinet shall also be supplied by vendor.

A power isolation switch with suitable circuit breaker or fuse shall be provided for the incoming power supply.

All items including analyser installed within the cabinet shall be suitable for the maximum possible temperature likely to be attained within the cabinet (i.e. with all items fully powered-on within the cabinet) and area classification specified in the purchaser's data sheet.
Heating/cooling of analyser cabinet shall be provided either when purchaser's data sheet specify the requirement of heating and/or cooling or recommended by the analyser manufacturer or found necessary by the manufacturer to meet following requirements:

i) The temperature induced measurement error exceeds ± 1% of full scale in the worst temperature conditions.

ii) The maximum allowable ambient temperature condition of any component within the cabinet exceeds its limits.

Whenever cooling is specified or found necessary, vendor may select one of the following cooling methodologies, unless specifically indicated otherwise:

a) Cabinet mounted air conditioner certified for the specified area classification.

b) Vortex cooler with compressed air system and air dryer of suitable size and capacity. No separate instrument air shall be provided by purchaser for vortex cooler.

c) The maximum height of rack/cabinet shall be limited to 2100 mm. Cabinet shall be suitable for side and bottom cable entry.

d) Power supply cable entry and terminal size shall be as defined during detail engineering by purchaser.

2.3 **Infra-Red/Ultra-Violet (IRIUV) Analysers**

2.3.1 IR/UV analyser shall preferably be non-dispersive type.

2.3.2 Analyser cell length shall be selected as per specified analyser component range. In case of dual range analysers, the selected cell length shall be suitable for both the ranges.

2.3.3 The analyser cell material and window material shall be suitable for the specified process condition. Unless otherwise specified or required otherwise by pressure-temperature conditions, the o-ring material shall be Teflon.

2.3.4 The analyser design shall be such that it is insensitive to source fluctuations or degradation or partial cloudiness of cell window.

2.3.5 Special filters shall be offered to minimise the interference of background components, which are of least interest in process stream.

2.3.6 Unless otherwise specified, analyser shall meet the following performance requirements:

<table>
<thead>
<tr>
<th>Repeatability</th>
<th>± 1% of full scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero drift</td>
<td>± 1% full scale per 24 hours.</td>
</tr>
<tr>
<td>Response Time</td>
<td>5 seconds for 90% of final reading</td>
</tr>
</tbody>
</table>

2.4 **Thermal Conductivity Analyser**
2.4.1 Thermal conductivity analyser shall be suitable for measuring hydrogen/hydrocarbon in binary gas mixture or in a multi component gas mixture.

2.4.2 Analyser shall have precise temperature controller which shall be able to maintain temperature within ± 0.1°C to ensure stable detector operation.

2.4.3 Analyser cell shall have flowing reference gas or sealed in (non-flowing) reference as per manufacturer's standard product.

2.4.4 The analyser sensor cell material shall be suitable for the specified process conditions, unless otherwise specified or required by temperature condition, o-ring material shall be PTFE.

2.4.5 Performance specification

Unless otherwise specified, Analyser shall meet the following performance specifications:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>± 1% of FSR</td>
</tr>
<tr>
<td>Repeatability</td>
<td>± 1% of FSR in 24 hours</td>
</tr>
<tr>
<td>Response time</td>
<td>Maximum 20 seconds for 90% response</td>
</tr>
</tbody>
</table>

2.5 Moisture Analyser

2.5.1 The requirements of moisture analyser for corrosive as well as non-corrosive for application are specified in this clause. Vendor shall offer the type of analyser as specified in the purchaser's data sheet.

Whenever, the type of analyser is not indicated in the purchaser's data sheet, vendor shall select the type of moisture analyser as per the specified process conditions.

2.5.2 Moisture analyzer for non-corrosive application.

2.5.2.1 The probe shall be in-line mounted (i.e. shall be located at the point of measurement) in general and shall not be damaged by severe shock and line abrasion conditions.

2.5.2.2 The pressure and temperature rating of the probe shall be suitable for the process condition specified in the data sheet.

2.5.2.3 When mounted remote, the probe shall be installed in a sample cell. The connections of sample cell shall be flanged with ANSI rating as specified in the purchaser's data sheets.

2.5.2.4 Unless otherwise specified or found necessary by vendor, no sample handling system shall be required. However, whenever the sample handling system is specified, the design shall ensure the integrity of sample i.e. moisture contents integrity shall be maintained.

2.5.2.5 The probe shall have Aluminum oxide moisture sensor. Alternate type moisture probe shall also be acceptable, if this meets the performance requirements specified in the purchaser's data sheet.
2.5.2.6 Each probe shall be supplied as pre-calibrated and shall be supplied with its own calibration curve. The calibration shall be valid for a period of minimum six (6) months from the date of supply, as a minimum.

2.5.2.7 Performance specification.

The moisture probe shall meet the following requirements as a minimum:

**Accuracy**: ±2°C within a range of 60°C to 65°C (Dew point)
± 3°C within a range of -66°C to -110°C

**Repeatability**: ± 0.5°C in range of 60°C to 65°C
± 1.0°C in range of -60°C to -110°C

**Life time**: One year

**Time Constant**: 5 seconds for 63% of steady state value.

2.5.3 Moisture analyser for corrosive application

2.5.3.1 The moisture probe shall be hygroscopic ally sensitized quartz crystal or equivalent suitable for the specified process samples containing unsaturated hydrocarbon, chlorides, oils etc.

2.5.3.2 Sample shall be conditioned in a sample handling system which shall include filters, condensate trap, dryer, pressure regulator (with or without heating as required) etc., however the design shall ensure that moisture integrity is maintained by the sample handling system.

2.5.3.3 The system shall incorporate a dried reference gas cycle after each sample gas measurement in order to strip volatile contaminants from the detector during reference gas cycle.

2.5.3.4 In order to ensure accuracy and reliability of the moisture analyser, the system shall incorporate a moisture generator, consisting of temperature controlled water reservoir and a permeation tube. The moisture generator shall generate a known moisture sample against which calibration of the analyser can be verified.

2.5.3.5 Performance Specification

The moisture probe shall meet the following performance requirements, as a minimum:

**Accuracy**: ± 5% of reading
**Repeatability**: ± 1% of reading
**Response time**: max. 60 seconds for 90 % of steady state value

2.5.4 Analyser Monitor/Controller

2.5.4.1 The analyser monitor/controller shall be microprocessor based and shall be programmable type.

2.5.4.2 The monitor/controller shall be remote mounted type with built-in display with keyboard for data display. The cable between analyser and monitor/controller shall be supplied by the vendor.
2.5.4.3 The monitor/controller shall be able to provide sequential display for various parameters and shall be selectable from the display keyboard.

2.6 Oxygen Analyser

2.6.1 The type of oxygen analyser shall be offered as specified in the purchaser's data sheet. Where purchaser's data sheet does not specify the type of oxygen analyser, vendor shall select the type meeting all functional and performance requirements indicated in purchaser's data sheets.

2.6.2 The analyser design shall ensure that the analysis is not affected by other sample constituents present in the sample.

2.6.3 Paramagnetic Type Oxygen Analyser

2.6.3.1 Unless otherwise specified, the paramagnetic type of oxygen analyser shall have magneto dynamic type measuring cell.

2.6.3.2. The analyser shall either have integral or split transducer unit containing the measuring cell and control unit containing the analyser electronics. The control unit facia shall have with LCD/LED display.

2.6.3.3 Whenever the control unit is remote mounted, cable between control unit and measuring cell shall be supplied by vendor.

2.6.3.4 Whenever paramagnetic type analyser is specified for pressurized or variable pressure application, the offered analyser shall have required pressure compensation to ensure that the measurement is not affected by changes in sample pressure and sample vent pressure.

The analyser design shall be such that the measurement shall not be affected by changes in ambient temperature and sample flow rate.

2.6.3.5 Paramagnetic analyser shall meet the following performance characteristics as a minimum:

- Accuracy : ±1% of full scale.
- Repeatability : ±0.5% of full scale.
- Response time : 6 seconds for 90% response

2.6.4 Electrochemical (Electrolytic) Type Oxygen Analyser.

2.6.4.1 The electrochemical type of oxygen analyser shall have either aqueous or non-aqueous measuring cell and shall meet the following requirement;

a) The analyser shall be self or auto-calibrating type. The calibration cycle shall be initiated either after a pre-defined time or whenever analyser senses excessive drop/drift in the output.
b) Analyser shall provide a suitable alarm for excessive drift. This information may be available as part of HART output signal.

2.6.4.2 In case, in those analysers where cell need to be replaced after the depletion of electrolyte, the analyser shall, in addition, meet the following requirements;

a) The electro-chemical cell shall be easily replaceable.

b) The analyser shall provide a warning for maintenance i.e. expiration of sensor well in advance (Typically 2 weeks). In addition analyser shall also provide an alarm in case output drops below the minimum reliable calibration level.

c) One spare cell shall be supplied as part of consumable spare.

2.6.4.3 The analyser shall have integral electronics with built in LCDILED display. Electrochemical analyser shall meet the following performance characteristics as a minimum:

- **Accuracy**: ±1% of full scale.
- **Repeatability**: ±1% of full scale.
- **Response time**: Less than 15 seconds for 90% response

2.6.5 Zirconia Type Oxygen Analyser

2.6.5.1 The Zirconia type oxygen analyser shall be either in-situ type or extractive type as specified in the purchaser's data sheet.

2.6.5.2 In case of in-situ type of analyser, vendor shall ensure that the analyser as offered is suitable for the pressure-temperature specified in the data sheet and the measurement shall not be effected by changes in sample pressure and flow rate. In case of variable pressure application, vendor shall ensure that offered analyser has the provision for pressure compensation and/or pressure balancing arrangement.

2.6.5.3 Zirconia type of oxygen analyser shall be provided with auto-calibration facility to take care of zero-drift of cell.

2.6.5.4 The zirconia analyser shall consist of the following sub-assemblies;

2.6.5.4.1 Sensor Assembly

a) The sensor assembly shall consist of the measuring cell, heater assembly, temperature sensor and connections for reference and calibration gases.

b) The measuring cell shall be a zirconia sensor specific for oxygen measurement.

c) The sensor shall be suitable for operating sample temperature up to 700°C.
2.6.5.4.2 Control Electronics

a) The control electronics shall have capability to execute all required controls, indications, temperature control for normal operation and output signals as specified in purchaser's data sheet.

b) Sensor temperature shall be maintained through temperature controller. Temperature sensor shall preferably be ISA type K thermocouple.

c) Temperature controller shall cut-off power to heater in case of thermocouple burns out.

d) Control electronics shall preferably be remote mounted type. Cable between control electronics and sensor assembly shall be supplied by vendor.

2.6.5.4.3 Reference Gas Control

Reference gas shall be flow and pressure controlled. Flow shall be controlled by rotameter With needle valve while pressure shall be controlled by self-actuated pressure control valve provided with pressure gauge.

2.6.5.5 Zirconia type oxygen analyzer shall meet the following performance characteristics as a minimum:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>± 2% of measured value.</td>
</tr>
<tr>
<td>Repeatability</td>
<td>± 1.0% of full scale.</td>
</tr>
<tr>
<td>Response time</td>
<td>Less than 10 seconds for 90% response.</td>
</tr>
</tbody>
</table>

2.7 Calibration Gas and Reference Gas Cylinders

2.7.1 Each analyser shall be supplied with following gases with stainless steel or Aluminum Cylinders:

a) Reference gas dual cylinder with manifold where required. The reference gas system shall be dedicated one for each analysers, where required along with automatic switchover to standby cylinder when the first cylinder is exhausted.

b) Certified calibration gases. In case of dual range of measurement, separate calibration gas for each range shall be provided.

2.7.2 Each of the gas cylinders shall be provided with two stage pressure regulator. Manifold shall be provided for reference gas with dual cylinder configuration.

2.7.3 All gas cylinders shall be located near the analyser and shall be supplied with gas cylinder rack with free standing support.

2.7.4 In case the calibration gas deteriorates or depletes with time, vendor may either supply calibration gas cylinders with deferred delivery or supply alternate devices for preparing calibration blend.
3.0 NAMEPLATE

3.1 Each analyser and its accessory shall have a stainless steel nameplate firmly attached to it at a visible place, furnishing the following information as applicable:

   a) Tag number as per purchaser's data sheets.
   b) Manufacturer's serial number and model number.
   c) Manufacturer's name/trade mark.
   d) Component being analysed and its range.
   e) Area classification in which the equipment can be used.
   f) Power supply requirements.
   g) Analyser Outputs

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at the vendor's works in line with the inspection test plan for process stream analysers. Vendor shall provide necessary facilities, utilities, competent manpower and consumables required for carrying out the inspection.
4.2 Vendor shall submit the following test certificates and test reports for purchaser's review for each of the analyser:

   a) Dimensional verification certificate for each analyser.

   b) Material test report as per clause 2.2 of EN 10204 for all wetted part

   c) Manufacturer's test reports as per clause 3.1B of EN 10204 for various bought out components.

   d) Leak test report for complete analyser system including sample handling system using Nitrogen or instrument air at 1.5 times the maximum working pressure.

   e) Calibration report for each analyser as per clause 4.3 of this specification.

   f) Repeatability test for each analyser as per clause 4.4 of this specification.

   g) Power supply variation check.

   h) Test certificates for zero, span, carrier and fuel gases as applicable.

   i) Certificates from statutory body for flameproof/intrinsic safety and weatherproof enclosures as applicable.

4.3 Analyser Calibration

4.3.1 Analyser along with sample handling system shall be calibrated using zero and span calibration gas samples in the following sequence:

   a) Check/adjust zero by connecting zero gas and span by connecting span gas.

   b) Check again zero by connecting zero gas after (a) above. Also repeat span gas check.

   c) If either or both zero and span are adjusted in step (b), repeat (b) again to verify the calibration until no further adjustments are made in zero and span.

4.4 Repeatability Testing

4.4.1 Repeatability of the analyser shall be checked by connecting either span gas (if it is approximately 70% of analyser span) or any other gas sample on continuous basis for the following time period.

   a) 24 hours by manufacturer and report to be submitted for review.

   b) 8 hours during witness inspection.

4.5 Witness Inspection

4.5.1 All the analysers shall be offered for pre-dispatch inspection by the purchaser at vendor works. Following tests/ checks shall be carried out on each analyser as a minimum:

   a) Physical dimensional verification and workmanship.

   b) Bill of material check for each analyser system including sample handling system...
c) Leakage testing of complete system using nitrogen or instrument air.
d) Calibration check as per clause 4.3 above.
e) Repeatability check as per clause 4.4.
f) Power supply variation check. Analyser must function satisfactorily on specified variation of power supply voltage.
g) Review of all test certificates and test reports indicated in clause 4.2 above.

4.5.2 In the event when the witness inspection is not carried out by purchaser, the tests shall any way be completed by the vendor and documents for same shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 All threaded and flanged openings shall be suitably covered to prevent entry of foreign material.

5.2 Each major part shall be sealed in thick plastic bag. Suitable moisture absorbent shall be provided for electronic components.

6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents, which are specifically indicated in the material requisition.

6.2 Any offer not conforming to the above requirements, shall be summarily rejected.
STANDARD SPECIFICATION

FOR

CALIBRATION GAS REQUIREMENT

& UTILITY CONSUMPTION
### Standard Specification for Calibration Gas Requirement & Utility Consumption

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Tag No.</th>
<th>Analyzer Type</th>
<th>ZERO gas cylinder with regulator pressure gauges and relief valve</th>
<th>SPAN gas cylinder with regulator pressure gauges and relief valve</th>
<th>Fuel/Carrier gas cylinder with regulator pressure gauges and relief valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Note 1</td>
<td>Note 1</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

**Note 1: Vendor to Provide the Tag and Analyzer Type**

1) Vendor shall supply calibration sample cylinders for zero and span calibration for each analyser. Quantity of total cylinders for each analyser shall be calculated by vendor with following basis:

   a) Calibration gases are required for six months of normal operation.

   b) These calibration gas cylinders for six-month operation shall be supplied in two sets. One set these cylinders shall be connected to the analyser and another set of cylinders shall be kept in store.

   c) Calibration gas accuracy shall be adequate to demonstrate the repeatability of the analysers.

   D) Calibration / Zero gas quantity shall be calculated based on a frequency of one calibration / fortnight interval as a minimum.

   e) Calibration gas cylinders shall be preferably of SS316 material. Aluminium gas cylinders are all: acceptable in place of SS316.

* - Vendor to offer total no. of cylinders accordingly and indicate the same in the offer.
1.0 Power Consumption:
(A) 415 VAC, 50Hz (For Air-conditioning, panel lighting, electrical heat)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Item</th>
<th>Maximum Power Consumption</th>
<th>In Rush Current</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unit Consumption</td>
<td>Total Consumption</td>
</tr>
<tr>
<td>1.</td>
<td>Note 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Note 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(C) 110 VAC +/- 10 %, 50Hz +/-3%, UPS (for Analyser and its sample handling system)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Item</th>
<th>Maximum Power Consumption</th>
<th>In Rush Current</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unit Consumption</td>
<td>Total Consumption</td>
</tr>
<tr>
<td>1.</td>
<td>Note 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Note 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2 Instrument Air:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Item</th>
<th>Normal (Nm3/hr)</th>
<th>Maximum (Nm3/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Note 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Note 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: 1. All utilities shall be made available to vendor at a single point near the cabinet for the Analyser system, further distribution or conversion if required shall be in Vendor scope. Vendor shall ensure the matching connection to the purchaser provided header connections.

Note 2 : Vendor to Provide the Tag
STANDARD SPECIFICATION

FOR

MASS FLOW METER
ABBREVIATIONS:

AARH  Arithmetic Average Root Height
CMRI  Central Mining Research Institute
ERTL  Electronics Regional Testing Laboratory
FISCO  Field Bus Intrinsically Safety Concept
HART  Highway Addressable Remote Transducer
HHT  Hand Held Terminal
NPS  Nominal Pipe Size
NPT  National Pipe Thread
PID  Proportional, Integral and Derivative
RAM  Random Access Memory
CONTENTS

1.0 GENERAL

1.1 Scope

2.0 DESIGN AND CONSTRUCTION

3.0 NAMEPLATE

4.0 INSPECTION AND TESTING

5.0 SHIPPING

6.0 REJECTION
1.1.1 This specification, together with the data sheets attached herewith covers the requirements for the design, materials, inspection, testing and shipping of mass flow meter.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest edition prior to the date of purchaser's enquiry;

<table>
<thead>
<tr>
<th>ANSI/ASME</th>
<th>American National Standards Institute / American Society of Mechanical Engineers.</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 1.2.1</td>
<td>Pipe Threads General Purpose (Inch)</td>
</tr>
<tr>
<td>B 16.5</td>
<td>Pipe Flanges and Flanged Fittings NPS ½ through NPS24</td>
</tr>
<tr>
<td>B 16.20</td>
<td>Metallic Gaskets for Pipe Flanges, Ring Joint, Spiral wound</td>
</tr>
<tr>
<td>B 16.34</td>
<td>Valves Flanged, Threaded and Welding Eng</td>
</tr>
<tr>
<td>EN 10204</td>
<td>Inspection Documents for Metallic Products</td>
</tr>
<tr>
<td>IEC-60068</td>
<td>Environmental Testing</td>
</tr>
<tr>
<td>IEC-60079</td>
<td>Electrical Apparatus for Explosive Gas Atmosphere.</td>
</tr>
<tr>
<td>IEC-60529</td>
<td>Degree of Protection Provided by Enclosures (IP code).</td>
</tr>
<tr>
<td>IEC-60587</td>
<td>Test Method for evaluating resistance to tracking and erosion of electrical insulating materials used under severe ambient conditions.</td>
</tr>
<tr>
<td>IEC-61000-4</td>
<td>Electromagnetic Compatibility for industrial Process Measurement and Control Equipments</td>
</tr>
<tr>
<td>IEC-61158</td>
<td>Field Bus Standard for use in Industrial Control System</td>
</tr>
<tr>
<td>IEC-61158-2</td>
<td>Physical Layer Specification and service definition for field bus.</td>
</tr>
<tr>
<td>IEC-61508</td>
<td>Functional Safety of Electrical / Electronic / Programmable Electronic safety related system.</td>
</tr>
<tr>
<td>IS-2148</td>
<td>Flameproof Enclosures for Electrical Apparatus for Explosive Gas Atmospheres - Flameproof Enclosures 'd'.</td>
</tr>
<tr>
<td>ITK-x.x</td>
<td>Interoperability Test Kit (latest version)</td>
</tr>
</tbody>
</table>

1.1.3 In the event of any conflict between this standard specification, job specification/ data sheets, statutory regulations, related standards, codes etc. the following order of priority shall govern:

a) Statutory Regulations
b) Data Sheets
c) Standard Specification

1.1.4 In addition to compliance to purchaser's specifications in totality, vendor's extent of responsibility shall include the following:

a) Purchaser's data sheets specify the minimum acceptable material for the body and sensor tube of mass flow meter. Alternate superior material of construction shall also be acceptable provided, vendor assumes full responsibility for the selected material for the indicated fluid and its operating conditions.

b) Sizing and selection of mass flow meter suitable to measure the specified fluid flow rate with the stated accuracy.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to the vendor attached with the material requisition.

1.2.2 Whenever a detailed technical offer IS required, vendor's quotation shall include the following:

a) Compliance to the specifications.

b) A detailed specification sheet for each item, which shall provide information, described as under. The material specifications and the units of measurement for various parts in vendor's specification sheet shall be to the same standard as those indicated in purchaser's data sheets.

i) Type of element and material of construction of various parts and its accessories.

ii) Accuracy of flow measurement at the specified minimum, normal and maximum flows with pressure drop not exceeding the maximum allowable pressure drop indicated in the purchaser's data sheet.

iii) Pressure drop across the mass flow meter at the maximum now specified in the data sheet.

iv) Special cable required, if any, cable specification and the maximum permissible cable length between the flow meter and its associated receiver instruments and unit rate.

c) Mass flow meter sizing calculations for each meter considering accuracy and pressure drop requirements specified in the purchaser's data sheets.

d) Effects of variations in density, viscosity, temperature and pressure on the measurement.

e) Proven reference for each offered model number in line with clause 1.2.3 of this specification, whenever specifically indicated in purchaser's data sheets.
f) A copy of approval from local statutory authority, as applicable, such as Chief of Controller of Explosive (CCE), Nagpur or Director General of Mines Safety (DGMS) in India for the mass flow meters installed in electrically hazardous area along with;

i) Test certificate from recognised house CMRI I ERTL etc. for flameproof enclosure / intrinsic safety, as per relevant standard for all Indian manufactured equipment or items requiring DGMS approval.

ii) Certificate of conformity from agencies like LCIE, BASEEFA, PTB, CSA, UL etc. for compliance to ATEX or any other recognised standard for all equipment manufactured outside India.

h) Deviation on technical requirements shall not be entertained. In case vendor has some valid technical reason to deviate from the specified requirements, they must include a list of mass flow meters tag number wise, summing up all the deviations from the purchaser's data sheets along with the technical reasons for these deviations.

i) Catalogues giving detailed technical specifications, model decoding details and other related information for each type of mass flow meter covered in the bid.

1.2.3 All items, as offered shall be field proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date in the process conditions similar to those as specified in the purchaser's data sheet. Items with proto-type design or items not meeting provenness criteria specified above shall not be offered.

1.2.4 Whenever specified, vendor must furnish tested values of failure rates, probability of failure detection and test intervals for the safety integrity level analysis.

1.2.5 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation manual, operation and maintenance manuals etc shall be in English language only.

1.2.6 Vendor shall also quote for the following:

a) Universal hand held configurator / terminal (HHT) for the configuration and maintenance of instruments with HART output.

b) Field bus hand held tester for configuration and maintenance of field bus network.

c) Field bus configurator with hardware and software for configuration and maintenance of field bus instruments.

d) Safety barriers whenever offered meters are certified intrinsically safe with external barriers.

e) Two year's operation spares for each mass flow meter and its accessories covered in the bid, which shall include the sensor, pre-amplifier, and converter electronics etc. as a minimum.
1.3 Drawings and Data

1.3.1 Detailed drawings, data, and catalogues required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of reproducible, prints and soft copies should be dispatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual submitted by the vendor after placement of purchase order, vendor shall include the following as a minimum:

a) Specification sheet for each mass flow meter.

b) Certified drawing for each mass flow meter, which shall provide:
   i) Dimensional details in mm.
   ii) Weight of the flow meter in kilogram.
   iii) Material of construction.
   iv) Installation requirements.

c) Curves for flow measurement vs, accuracy and rangeability.

d) Maximum and minimum supply voltage required for the instrument to function within the stated performance characteristics.

e) Clearance required for maintenance work

f) Copy of type test certification

g) Calibration procedures for mass flow meter.

h) Copy of test certification for all the tests indicated 111 clause 4.0 of this specification.

i) Installation procedures for mass flow meter.

2.0 DESIGN AND CONSTRUCTION

2.1 Flow Meter

2.1.1 Flow meter shall be of in-line mounting design with flow direction clearly marked on the flow meter body to ensure correct installation.

2.1.2 Flow meter design shall ensure that the location and orientation of installation of mass flow meter in the line shall not affect the calibration, accuracy and performance of the meter.
2.1.3 The material of construction of mass flow internals and body shall be as specified in the respective data sheets, as a minimum.

2.1.4 The mass flow meter shall be provided with the external flow tube housing wherever specifically indicated in the data sheet. In all such cases, the now tube housing shall have provision to monitor housing pressure continuously.

2.1.5 The mass flow meter shall have high vibration immunity. The meter output shall not be effected by the pipeline vibration where the meter is installed.

2.1.6 End Connection

2.1.6.1 Flow meter shall be of flanged body construction with material if construction as specified in purchaser's data sheet. In case meter design where end flanges are welded to the meter body all weld joints shall be of radiography quality.

2.1.6.2 Flow meter shall be of flanged body construction with material of construction as specified in the purchaser's data sheet. In case of meter design where end flanges are "welded to the meter body all weld joints shall be of radiography quality.

2.1.6.3 Unless otherwise specified, the following shall govern:

a) Threaded end connections shall be to NPT as per ANSI/ASME B 1.20.1.

b) Flanged end connections shall be as per ANSI/ASME B 16.5.

c) Flange face finish shall be as per clauses 6.4.4.1,6.4.4.2 and 6.4.4.3 of ANSI/ASME B16.5. The face finish as specified in data sheets shall be as follows:

   125 AARH : 125 TO 200 AARH

   63 AARH : 32 TO 63 AARH

2.1.7 Terminal Housing

2.1.7.1 Following shall apply for both integral as well as for remote meter electronics:

a) All connections shall be terminated on the terminals brought out in the terminal housing located on the flow meter body. Flying leads shall not be provided.

b) All intrinsically safe terminals shall be properly identified and shall be separate from the non-intrinsically safe terminals.

c) Separate cable entry shall be provided in the terminal housing for power and intrinsically safe signals.
d) The flow meter enclosure, housing the electrical parts shall be suitable for the area classification indicated in the purchaser's data sheets. Unless otherwise specified, the enclosure shall conform to the following standards, as a minimum:

Weatherproof housing - IP 55 to IEC-60529/IS-13947.
Flameproof housing - Flame proof / Ex (d) as per IEC-60079/1S-2I48.

Flameproof housing shall also be made weatherproof.

2.2 Meter Electronics

2.2.1 Flow meter electronics shall be microprocessor based and shall include pre-amplifier, converter, transmitter electronics and integral output meter. The indication on the output meter shall be digital with engineering units.

2.2.2 The mass flow meter transmitter shall be smart type and shall provide 4-20mA analog output superimposed with digital signal for meter diagnostics (HART Output). When specified, flow meter shall provide field-bus output conforming to the standard specified in the purchaser's specification sheets.

2.2.3 The mass flow meter shall be capable of computing field density and shall incorporate temperature sensor flow fluid temperature measurement. Whenever specified in the purchaser's data sheets, the flow meter electronics shall have capability to compute volumetric flow rates.

2.2.4 The meter electronics shall be protected against transients induced by lightning and power supply surges. Transient protection electronics shall preferably be provided in the terminal block. The transient protection shall meet the requirements specified in IEC-60537.

2.2.5 The configurational data of the instrument shall be stored in a non-volatile memory such that this remains unchanged because of power fluctuations or power off condition. In case, vendor standard instrument has battery backed RAM vendor to ensure that battery drain alarm is provided as diagnostic maintenance message.

2.2.6 For smart transmitters or for field bus based transmitter the following features must be ensured;

i) It shall allow multi master (primary and secondary) for configuration, calibration, diagnosis and maintenance. The primary could be the control system or host computer, and the secondary could be the hand held communicator.

ii) It should be capable of implementing universal command.

2.2.7 In addition to the requirements specified above, field bus based transmitter requirements;
a) All instruments must satisfy the requirements of the field bus registration laboratory with applicable checkmark like foundation field bus, profibus PA, or as specified in the purchaser's data sheets.

b) All instruments shall have two analog input blocks, as a minimum. In addition, when specified the transmitter shall also have PID controller block.

c) All instruments must be interoperable and shall have valid interoperability test clearance like ITK 4.6 for foundation field bus or equivalent for profibus PA, as applicable.

d) The field bus instruments shall support peer-to-peer communication.

e) Field bus instruments as offered shall not be polarity sensitive.

f) The field bus instruments in hazardous area shall be certified as per entity concept or shall be FISCO approved as per the requirements specified in the purchaser's specification.

2.2.8 Meter electronics shall also be provided with security lockout feature to disable access to configuration modification features.

2.2.9 Flow meter electronics shall be either integral to flow meter or shall be remote mounted type. Where remote mounted electronics is offered a minimum of 10 metres of interconnecting cable shall be included.

2.2.10 Flow meter electronics shall have enclosures suitable for the hazardous area classification indicated in purchaser's data sheets. When area classification is specified as electrically hazardous flow meter shall have flameproof enclosure with intrinsically safe circuitry for sensor connectivity. Safety barrier if required for the sensors shall be part of transmitter enclosure.

2.2.11 The meter electronics along with flow meter shall be pre-calibrated at vendor's works with calibration factor duly established for the flow meter.

2.2.12 The meter electronics shall be immune to RFI and EMI radiation and shall be in compliance with the electromagnetic compatibility requirement as per IEC 61000-4.

2.2.13 Purchaser will provide one no. of feeder for 110 V AC ± 10%, 50 Hz power supply at the transmitter. Further distribution if any shall be taken care of by vendor. Accessory like cable gland, conduit and junction box as required to interconnect sensor, transmitter signal cable etc., shall be supplied by the vendor.

Supply voltage fluctuation of ± 10 per cent from the specified value and supply frequency fluctuation of ± 3 Hz from the specified value shall not affect the meter performance.

2.2.14 Meter electronics housing shall meet the terminal housing requirements specified in Clause 2.1.7 of this specification.

2.3 Meter Sizing
2.3.1 The meter shall be sized considering the following guidelines:

a) Minimum flow, maximum flow and meter maximum as specified in the purchaser's data sheet.

b) Flow accuracy between the minimum and maximum flow specified in the data sheet. Where only normal flow is specified, the maximum and minimum flows considered for the purpose of sizing shall be;

   Maximum flow = 1.4 times the normal flow

   Minimum flow = 0.4 times the normal flow

   When only maximum flow is specified minimum flow shall be considered as 0.2 times the maximum flow for sizing the meter.

   a) The maximum pressure drop at meter maximum shall not exceed the allowable pressure drop across the meter specified in the data sheet.

   b) The meter shall be selected such that both accuracy and allowable pressure differential across the meter are complied.

2.4 Performance Requirements

2.4.1 Unless specified otherwise in the purchaser's data sheets, the performance requirements for the mass flow meter shall be as follows;

   a) Flow meter repeatability: ± 0.2% of mass flow rate for liquid service.
   ± 0.5% of mass flow rate for gas / vapour service

   b) Flow meter accuracy: ± 0.1% of mass flow rate for liquid service
   ± 0.25% of mass flow rate for gas / vapour service

   The performance requirements specified above excludes the effect of zero stability of the flow meter on these parameters.

2.5 Accessories

2.5.1 Hand held configurator for Smart Instruments

Hand Held configurator shall be universal type and shall be able to communicate with all make and models of smart instruments with HART output like transmitters, smart positioners etc., and shall be capable of carrying out all engineering like calibration, configuration and diagnostics. The hand held configurator shall be certified intrinsically safe when used in hazardous area. Carrying case shall be supplied with each configurator.

2.5.2 Field bus hand held tester
The field bus hand held tester shall be able to communicate with the specified field bus instrument and shall be capable of calibrating and configuring field bus devices. The field bus hand held tester shall be certified intrinsically safe when used in hazardous area. Carrying case shall be supplied with each tester.

2.5.3 Field bus configurator

The field bus configurator shall be a centralised device like personal computer with hardware and software suitable for configuration and maintenance of field bus instruments.

2.5.4 Battery charger

Both field bus hand held tester and hand held configurator for smart instruments with HART output shall be supplied with battery charger for battery charging of hand held configurator / field bus tester. Unless otherwise specified, battery charger shall operate at 220V 50Hz supply.

3.0 NAME PLATE

3.1 Each mass flow meter and its accessories shall have a stainless steel nameplate attached firmly to it at a visible place, furnishing the following details as applicable.

a) Tag number as per purchaser's data sheets.
b) Manufacturer's model number and serial number.
c) Manufacturer's name/trade mark.
d) Nominal end connection size in inches and rating in lbs (#).
e) Body and trim material.
f) Area classification in which the equipment can be used.
g) Standard for body/trim materials (eg. ASTM)
h) Enclosure type

i) Calibrated range and unit of measurement of flow.

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at the vendor's works, in line with the inspection test plan for mass flow meters.

4.2 Vendor shall submit the following test certificates and test reports for the purchaser's review:

a) Material test certificate as per clause 3.1B of ENI 10204.
b) Certificate from statutory body for intrinsic safety and explosion proof enclosures.
c) Type test certificate for weatherproof enclosures.
d) Certificate of radiography/X-ray for weld joints, wherever specified. Dye penetration check shall also be carried out for all weld joints.

e) Hydrostatic test reports as per clause 4.3 of this specification.

f) Flow calibration and performance test report including calibration factors for each meter as per clause 4.4 of this specification.

g) Capability of smart and field bus based transmitters to accept multimasters for configuration, calibration, diagnostics and maintenance.

h) Configuration, calibration and diagnostics check through hand held configurator / field bus tester for smart / field bus based instruments.

i) Configuration, calibration and diagnostics check through field bus configurator for Field bus based instruments.

j) Interoperability test certificate as per clause 2.2.7 c) of this specification.

k) Dimensional test report for each mass flow meter.

4.3 Hydrostatic Test

4.3.1 Each mass flow meter shall be subjected to hydrostatic test at test pressure equal to 1.5 times the maximum allowable working pressure at ambient temperature in accordance with ANSI B 16.34. There shall not be any visible leakage during the test.

4.4 Calibration

4.4.1 Each mass flow meter shall be calibrated with the fluid for which it is expected to be used. Else, vendor must indicate;

a) Fluid used for calibration

b) The correction factor / adjustment required for the actual process fluid.

4.5 Witness Inspection

4.5.1 All mass flow meter shall be offered for pre-dispatch inspection, for the following as a minimum:

a) Physical dimensional verification and workmanship.

b) Hydrostatic test as per clause 4.3 of this specification on representative sample.
c) Performance testing including establishing accuracy and repeatability over the entire range and calibration testing, on the representative samples.

d) Capability of smart and field bus based transmitters to accept multimasters for configuration, calibration, diagnostics and maintenance.

e) Configuration, calibration and diagnostics check through hand held configurator / field bus tester for smart / field bus based instruments.

f) Configuration, calibration and diagnostics check through field bus configurator for field bus based instruments.

g) Review of all certificates and test reports as indicated-in clause 4.2 of this specification.

4.5.2 In the event when witness inspection is not carried out by purchaser, the tests shall be any way completed by the vendor and the documents for the same shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 All threaded and flanged openings shall be suitably protected to prevent entry of foreign material.

5.2 The mass flow meter remote electronics and its accessories shall be packed separately.

6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents, which are specifically indicated in the material requisition.

6.2 Any offer not conforming to the above requirements, shall be summarily rejected.
STANDARD SPECIFICATION

FOR

ERECITION TENDER
(INSTRUMENTATION)
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1.0 GENERAL

1.1 This technical specification covers in general the scope of work, scope of supply, execution methodology and criteria for handling scrap and excess material and various other requirements, which are required to be met during the course of execution of instrumentation works.

1.2 Instrumentation works shall be performed in accordance with this technical specification and various other drawings and documents supplied during the execution of work and instructions of Engineer-in-charge or his authorised representative(s) from time to time during the progress of the work.

1.3 Standards

The instrumentation erection and calibration works shall be carried out in accordance with various national, international and Indian Standards in instrumentation listed below but not limited to the following. The standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry.

API American Petroleum Institute
MPMS - Manual of Petroleum Measuring Standards
RP - Recommended Practices
BS-6739 Instrumentation in process control systems: Installation design and practice
ISA Instrumentation, Systems and Automation Society Standards, Recommended Practices, and Technical Reports
RP 7.1 Pneumatic Control Circuit Pressure Test
IS-5 Colours for ready mixed paints and enamels
IS-2074 Ready mixed paint, air drying, red oxide-zinc chrome priming
IES 60529 Degree of Protection Provided by Enclosures (IP Code)
IEC 60079 Electrical Apparatus for Explosive Gas Atmospheres
IS-13947 Specification for Low Voltage Switch gears and Control gears
IS-2148 Electrical Apparatus for Explosive Gas Atmosphere-Flame proof Enclosures 'd'
Duct Fabrication - Welded Construction Detail
Duct Fabrication - Bolted Construction Detail
Instrumentation Installation Standards attached with the tender
Instrumentation supports standards
Manufacturer's standards and practices
Welding specification for fabrication of piping
Welding specification for piping classes

Specification for Non-Destructive examination of Piping

2.0 DEFINITIONS

2.1 Close coupled Installation

The installations where the distance of the instrument is within 600 mm from the primary tapping are termed as close coupled installations.

2.2 Remote Installation

The installations where the distance of the instrument is more than 600 mm from the primary tapping are termed as remote installations.

2.3 Manifold

2.3.1 For close coupled installation, 'Manifold' shall mean complete piping of instruments from first block valve upto the instruments.

2.3.2 For remote installation, 'Manifold' shall mean the assembly of nipples, valves and fittings around the instrument to form a block and bleed or bypass or drain, as the case may be. These shall be generally according to the installation standards enclosed with the tender. Wherever the instruments are installed with pre-fabricated 2-way, 3-way or 5-way valve manifold, the definition shall not be applicable as they are considered part of the instrument.

2.4 Instrument Impulse Line

Instrument impulse line shall mean piping and/or tubing from the first block valve upto the instrument including for drains and vent as applicable for an installation.

2.5 First Block Valve

First block valve shall mean the valve/values, which are generally mounted directly on equipments, columns, vessels, pipes, standpipes etc. and shall be operated to isolate the instrument and interconnected instrument impulse lines.

2.6 Supports

Supports shall mean the Mild Steel angles, flats, channels which are generally provided to support the main cable trays, cable ducts, junction boxes, angle trays, perforated trays, instrument piping, signal tubing, instrument air supply lines etc., at specified intervals from the instruments, concrete columns etc., to keep all items firmly secured against vibration, warping, bending etc.

2.7 Instrument Stanchion
Instrument stanchion shall mean the mounting arrangement necessary for the installation of one or more instruments and junction boxes. These shall consist of pipes, supports, clamps and fasteners as per applicable standards.

2.8 Scrap

2.8.1 Salvageable Scraps

Salvageable scrap shall mean the cut piece lengths recovered after consumption of tubes, pipes, multicables, other cables etc. that can be used one time or the other at a later date.

2.8.2 Non Salvageable Scrap

Non-salvageable scrap shall mean the cut piece lengths recovered after consumption of tubes, pipes, multi cables, cables etc. that cannot be used at all, at any time.

3.0 SCOPE OF WORK

3.1 Contractor's scope of work shall include the following:

a) Complete instrument erection work with details as listed under schedule of quantities attached elsewhere in the tender document.

b) Supply of all hardware such as lugs, ferrules, LI-clamps, washers, nuts, sealant, sealing tape, anchor fasteners, welding electrodes/filler wires, NDT test materials / Dye penetrant spray etc and carry out all residual activities not listed specifically in schedule of quantities but are necessary to ensure proper execution and completeness of instrumentation work.

c) Supply of all items specifically listed in the schedule of quantities as per specifications attached elsewhere in the tender document.

d) As-built construction drawings and documents as detailed out in this specification.

e) Arranging all necessary test and calibration equipments as per the details provided in this specification.

f) Any other work, not specifically listed, but necessary for the successful completion of instrumentation erection work defined in this specification or the schedule of quantities.

3.2 Work Included

The various jobs covered under instrumentation erection work are detailed out in the schedule of quantities. However to ensure proper execution and completeness of works any or all of the following activities, as necessary, shall also form part of the contractor's scope of work.

The price of all such activities shall be covered in the rates quoted against the various activities covered under schedule of rates.

3.2.1 Fabrication of pipe nipples, as necessary, from the running pipe including cutting of pipes and making threads as necessary, as per installation standards.
3.2.2 Drilling of holes in blind flanges including threading, as necessary, as per installation 
Standards, wherever required.

3.2.3 Filling of seal pots and/or impulse lines, as applicable, with filling liquids as per the 
instructions of engineer-in-charge including supply of seal fill liquid.

3.2.4 Back/seal welding of screwed fittings and screwed connections as required by standards or as 
per the instructions of Engineer-in-charge. This may involve welding of dissimilar materials using 
appropriate electrodes/filler wires.

3.2.5 Dye penetration/magnetic particle test shall be carried out for all weld joints irrespective of their 
pipe classes and the charges for the same shall be included in the quoted rates of instrument 
installation.

3.2.6 Installation of devices like purge rotameter, restriction orifice plate, pressure gauge etc, as 
Applicable for purged installation, for instruments, instrument systems and pipelines as per 
installation standards.

3.2.7 Civil works including casting of foundation as required for instrument supports, stanchions etc, 
where paved surfaces do not exist.

3.2.8 Minor civil works like chipping of pavement, grouting of instrument panels/supports/stanchions on 
the pavement, laying of conduits below pavement after 
chipping and refinishinof pavement as necessary.

3.2.9 Sealing of cables/tubes entries into the control room after laying and testing of all cables/ 
tubes by filling with sealing compound including supply of sealing compound. Wherever the 
sealing of cables/tubes entries into the control room is by MCT frame/blocks, fixing of MCT 
frame and blocks shall be carried out by contractor as covered in the schedule of quantities.

3.2.10 Degreasing of hand wheels of control valves, stud bolts, nuts of side and bottom flange of control 
valves, stud bolts and nuts of orifice flanges/ or other primary elements and 
degreasing of any other instrument as per manufacturer's instructions or as required by 
Engineer-in-charge.

3.2.11 Degreasing of impulse lines, instrument valves, instruments and other instrument items in 
oxygen and chlorine service as per manufacturer's instructions or as required by engineer-
incharge.

3.2.12 Rotation of top works of displacer type level instruments, wherever required.

3.2.13 Rotation of control valve bonnet etc, wherever required.

3.2.14 Reversing the action of control valves either by replacement of actuator springs and 
accessories or positioner, wherever required, as per manufacturer's instructions.

3.2.15 Minor modifications/repairs required to be carried out on the instruments namely, 
replacement of dial and/or glass for pressure gauges/temperature gauges or any other similar 
instrument, replacement of rotameter tubes and level gauge glasses, replacement of damaged
signal tubes on control valves, tapping of damaged threads on couplings, tees and other fittings, cleaning of nozzles and relays in pneumatic instruments.

3.2.16 Painting of all structural supports required for trays, pipes, junction boxes, instruments, ducts as per painting specification or as instructed by Engineer-in-charge.

3.2.17 Identification of instruments/impulse lines/manifold connected with trip circuit in red color of paint.

3.2.18 Punching of tag num bers and supply of stainless steel tag plates wherever required as per instructions of Engineer-in-charge.

3.2.19 Fabrication and installation of pipe stanchion as per instrument support standards including casting of concrete pedestal, grouting, welding etc. as necessary. The type of instrument stanchions shall be at the discretion of Engineer-in-charge.

3.2.20 Drilling holes in the gland plate for providing glands/grommets on panels, shut down cabinets, power supply cabinets, local control panels, pneumatic enclosures, junction boxes etc., wherever required for cables/multi tubes entry.

3.2.21 Grounding of shields of shielded cables to respective instrument earth bus provided in the control room/local control room/local panel/analyser shelter/thermocouple head etc. as required and instructed by Engineer-in-charge.

3.2.22 Laying and termination of earth cable at both ends between instrument earth bus provided in the control room/local control room/local panel to instrument earth pits provided by other contractors unless specified otherwise.

3.2.23 Grounding of one of the thermocouple lead in the head using 10K ohm resistance including supply of resistance for grounded thermocouples.

3.2.24 Loop validation of all temperature elements (Thermocouples/RTDs) upto control room Including verification of element integrity, i.e. element open or element short.

3.2.25 Supply of all types of consumables required for the execution of the job without any exception.

3.2.26 Sealing of safety valves with standard lead seals after final setting and fixing of blind tapes in inlet/outlet of safety valves to prevent dust, in the presence of Engineer-in-charge.

3.2.27 Coordination during installation, pre-commissioning and commissioning with mechanical and other sub-contractors for proper installation of line mounted instruments like control valves, orifice assemblies, turbine meters, positive displacement meters, magnetic flow meters, mass flow meters, ultrasonic flow meters etc., which involve removal of instruments, disconnection of tubes/ables, reconnection of the same for alignment and proper installation.

3.2.28 Coordination during pre-commissioning/commissioning with mechanical and other subcontractor for proper installation of vessels/equipment mounted instruments like level transmitters, level gauges, level switches etc. which involves removal of instruments, disconnection of tubes/cables, reconnection of the same for alignment and proper installation.
3.2.29 Coordination with control system vendors (Distributed Control System/Programmable Logic Controller/Analyser system/Tank farm automation/Fire and G as detection system/Machine Monitoring System/Terminal Automation etc.), as necessary, during installation, loop checking and commissioning as per instructions of Engineer-in-charge. Contractor shall also coordinate with Des vendor for all arrangements and facilities required in the field during the testing of field bus instruments like signal level, noise, waveform etc., including mobilization of necessary test equipments in field.

3.2.30 Coordination with tank fabricator during installation of mechanical float type and Servo type of Tank Level instruments.

3.2.31 Removal of false floor slabs and re-fixing, as required, for laying of cables below false floor inside control room/rack room.

3.2.32 Shifting of instruments and materials from owner' warehouse/designated place to the work spot, providing suitable storage space and keeping the materials in safe custody and identification of special materials like alloy steel with proper color coding as per instructions of engineer-in-charge. Contractor shall also return the un-used materials including scrap to the owner's warehouse/designated place as per instruction of Engineer-in-charge.

3.2.33 Coordination with mechanical contractor during fire insulation of cable duct and cable trays.

3.2.34 Submission of monthly material appropriation statements for cables, tubes, piping materials and fittings, indicating the quantity issued and consumed in standard performa.

3.2.35 Incorporation of all information in owner's drawings/documents, as per actual execution of work at site including preparation and submission of as-built drawings.

3.2.36 Start-up and commissioning assistance as required and agreed upon with Engineer-in-charge.

3.2.37 Submission of final material appropriation statements for all the materials issued by the owner.

3.2.38 Any other work not specifically mentioned above, but required for the proper execution of the instrumentation erection work.

3.2.39 Where requested by owner/engineer-in-charge or his authorized representatives, all or any of the works detailed above and in schedule of quantities shall also be performed on package units, local panels/cabinets/gauge board installed by owner or by others.

3.3 Work Excluded

3.3.1 Installation of main panels, cabinets and consoles supplied by control system vendor inside control room unless specified otherwise.

3.3.2 Installation of line mounted instruments like control valves, orifice plates and flanges.
3.3.3 Mechanical installation of tank level instruments except radar gauges.

3.3.4 Installation of safety valves, breather valves, flame arresters, rupture dises.

3.3.5 First block valve for instrument tapping points on piping and equipments.

3.3.6 Insulation of steam traced instrument primary impulse lines.

3.3.7 Insulation of cable duct and cable trays for fire safety.

3.3.8 Painting of impulse lines.

4.0 EXECUTION METHODOLOGY

4.1 Instrument Impulse lines

4.1.1 All impulse lines shall be installed in the best workman like manner and shall follow installation standards in each case Where there is no installation standard, the instruction of the Engineer-in-charge shall be followed.

4.1.2 Horizontal and vertical lines shall be installed using levels and plumb bobs.

4.1.3 Unless otherwise specified in the drawings, impulse lines shall have a slope of not less than in 12 on the horizontal runs.

4.1.4 All welding shall be carried out as per codes and after approval of welding procedures and electrodes by Engineer-in-charge. Only qualified welders approved by Engineer-in-charge shall carryout welding. The following activities shall be part of contractor’s scope of work.

4.1.4.1 Welder qualification including supply of any materials required like electrodes, equipments, consumables, testing charges for various tests etc., required for initial qualification and subsequent validation till the completion of the job.

4.1.4.2 Welding procedure qualification including supply of any materials required for the qualification like electrodes, equipments, consumables, testing charges for tests etc. Contractor scope includes welding procedure qualification for welding of dissimilar materials as envisaged for any process hookup, wherever applicable.

4.1.4.3 The charges towards Positive Material Identification (PMI) shall be quoted as per the schedule of quantities attached elsewhere in this tender document. The equipment required for PMI testing shall be arranged by the contractor.

4.1.4.4 The charges towards non-destructive testing like radiography and post weld heat treatment shall be quoted as per the schedule of quantities attached elsewhere in this tender document.
The contractor is required to carry out 100% radiography of all the butt weld joints covered in the indicated installation standards.

For all other installations involving butt weld joints, not covered under 100% radiography requirement above, 10% radiography shall be carried out by the contractor. The charges for these shall be included in the quoted rates of installation of instrument, covered under schedule of quantities.

4.1.5 Welding and Non-Destructive testing shall be carried out by the contractor as per the following specifications or their respective job specifications.

4.1.5.1 Welding Specification for Piping Classes

4.1.5.2 Welding Specification for fabrication of piping

4.1.5.3 Specification of Non-Destructive Examination Requirement of piping to carry out the radiography, stress relieving, dye penetration test, magnetic particle test, wet fluorescent magnetic particle test etc.

4.1.6 Impulse pipes shall be bent using pipe benders only and hot bending will be totally rejected.

Pipes shall be cut using pipe cutting device. Hot cutting shall not be allowed.

4.1.7 Piping/tubing for steam tracing shall be installed according to the standards without any pocket so as to avoid formation of the condensate pockets.

4.1.8 All threaded joints shall be jointed with PTFE tape only. No other pipe jointing compound shall be used except on high temperature service where graphite sealing compounds shall be used.

4.1.9 All impulse lines shall be properly supported at regular intervals of 1 meter. Wherever insert plates are not available, supports on concrete structures or on ceilings shall be fixed with a minimum of 10 mm expansion bolts. Angle supports shall be fabricated from 40 mm x 40 mm x 5 mm MS angles, as a minimum.

4.2 PVC Covered/Bare Tube (Copper/SS/Aluminium)

4.2.1 Single copper/SS/A1uminium tubes shall be laid as per standards on perforated trays. The width of the trays shall be selected as per the number of tubes laid. Tubes shall be clamped to the trays at every 300 mm using clamps made of galvanised steel/aluminium strips. The practice of flattening tubes for clamping purposes shall not be permitted. In case of PVC covered tubes, any exposed portion at ends and connection shall be neatly taped to appropriate thickness. Open ends shall be covered to prevent ingress of moisture, dust, vermin etc. Plugs should be removed only when final connection is made.

4.2.2 Trays shall be properly supported either from any rigid steel structure or concrete member as detailed in clause 4.7.4 of this specification under trays and supports.

4.2.3 All threaded ends of male/female tube connectors shall be installed with PTFE tape only. Identification tag plates/ferrules shall be provided on either side of copper tubing as per
4.3 Installation of Multitubes And Multicore Cables

4.3.1 Multicore cables/multitubes shall always be installed on ducts/trays and shall be properly clamped. At every vertical drop to junction boxes, they shall be clamped at more frequent intervals (maximum of 300 mm). They shall be connected inside junction boxes strictly according to the number system as mentioned in cable schedule. At bends minimum radius shall be maintained as per manufacturer's standard. The angle tray supports shall be fabricated from 40 mm x 40 mm x 5 mm angles, as a minimum.

4.3.2 Identification tags shall be provided on either end of multitube/multicore cables as per tubing/cable schedules. Engraved tag plates or PVC ferrules shall be used for identification of tubes/cables.

4.3.3 All multitubes/multicore cables shall be cut after the exact site measurement are taken between ends. The tube/cable drums shall be selected before cutting the lengths so as to avoid any wastage.

4.3.4 All multicables and multitubes laid in ducts shall be properly dressed and tied with nylon wires of 3 mm diameter.

4.3.5 In the field, the cables and tubes shall be laid in ducts and trays as per layout drawings. Cables shall also be buried underground or taken in concrete trenches wherever required.

4.3.6 The grounding of shields for shielded cables shall not be carried out at field instrument and junction box end. The shields at these ends shall be suitably insulated from the body of the instruments/junction boxes.

4.3.7 In side the control room, all cables shall be laid in concrete trenches or below false flooring. When laid below the false floor, the cables shall be properly dressed and tied as per the instructions of Engineer-in-charge.

In other plant rooms like analyser room or local control rooms, the cables shall be laid in concrete trenches, unless specified otherwise.

4.4 Installation of Instruments

4.4.1 All instruments shall be generally installed on supports as per installation standards, instrument location plan and instructions of Engineer-in-charge. All the instruments installed shall be accessible for easy maintenance.

4.4.2 Receiver gauges shall be mounted on instrument support itself, as far as possible, as per tubing hookup standards.

4.4.3 Filter regulators shall be mounted on the instrument support below the instruments or on the control valve yoke, as far as possible.

4.5 Instrument Air Supply
4.5.1 The main instrument air header in each area is laid by other contractor. Air supply from the main air header take off valve to individual instruments shall be through either galvanized steel pipe or PVC covered copper tube or stainless steel tubes. The connections shall be screwed through out and no welding is permitted. The threading in galvanized pipes/nipples shall be carried out by contractor as per requirement.

4.5.2 Individual take off valves shall generally be located on top of the main air header. Unions shall be provided at convenient locations. There shall be one isolation valve at each instrument end. The galvanised pipe shall be supported at a minimum interval of 1.5 meters with 40 mm x 40 mm x 5 mm MS angles. Final connection to the instrument shall be copper/stainless steel tubing as per tubing hookup standards.

4.6 Instrument Steam Tracing

4.6.1 The main steam header in each area is laid by other contractor. From the main steam header take off valve, steam to individual instruments shall be taken through carbon steel pipes supported at regular intervals. Steam tracing around individual instruments shall be by copper tubes/stainless steel tubes, in general. After steam tracing, the line is connected to the drain funnel through individual steam trap/condensate return header/tapping point as the case may be.

4.6.2 Electrical tracing shall be done by others. Assistance, if required, shall be provided by the contractor as per instructions of Engineer-in-charge.

4.7 Cables Ducts/Ladder trays/perforated trays/angle trays and supports

4.7.1 Galvanised main cable trays are generally prefabricated ladder type trays and shall be laid as per layout drawing.

4.7.2 Closed ducts and ladder type MS angle type trays are generally fabricated as per the drawings and shall be laid as per layout drawings.

4.7.3 Generally heavy structural supports for cable ducts, ladder trays are provided by other agency. However, in critical areas, where additional supports are required to be provided in the opinion of the Engineer-in-charge, the same shall be provided by the contractor.

4.7.4 The perforated trays/angle trays shall be properly supported at a regular interval of maximum of 1 metre from insert plates or steel structures. Wherever insert plates are not available, supports on concrete structures and ceiling shall be fixed with minimum 10 mm diameter expansion bolts. Angle supports for perforated trays/angle trays shall be fabricated from 40 mm x 40 mm x 5 mm MS angles as a minimum.

4.7.5 All supports shall be cut with hacksaw only. Any work executed by gas cutting for making holes and cutting pieces will be totally rejected. Free ends of angle support shall not have sharp edges and shall be properly rounded off.

4.7.6 Perforated trays/angle trays shall be used for branch cables and tube from main trays. Width of trays shall be selected according to number of tubes and cables. Trays shall be laid generally as per site conditions with the approval of Engineer-in-charge.
4.7.7 No welding on galvanised trays/perforated trays shall be allowed in general. In specific cases where welding is unavoidable, this shall be carried out as per instructions from engineer-in-charge. For welding, if required, following procedure shall be followed as a minimum:

   a) Remove galvanisation thoroughly from the portion to be welded.
   b) After welding, clean the welded portion for any slug, sharp edge.
   c) Welded portion shall be painted as per procedure described under clause 4.10.

4.7.8 Main cable ducts, fabricated ladder type angle trays, MS perforated trays and their supports shall be painted as per painting specification detailed in clause 4.10.

4.8 **Laying of Cables**

4.8.1 All cables shall be laid in accordance with installation drawings and cable schedules. Before laying, cable/multicable on drums shall be meagre and tested to ascertain the transit damages. In case of field bus cables, the loop resistance and capacitance shall be checked by the contractor after the completion of cable laying.

4.8.2 All cables routes shall be carefully measured and cables cut to the required lengths, leaving sufficient amount for the final connection of the cable to the terminals on either end. The various cable lengths cut from the cable reels shall be carefully selected to prevent undue wastage of cables. Sufficient extra length of cable shall be kept at the termination points.

4.8.3 A detailed planning shall be submitted prior to cable laying, giving drum number, cable number, lengths which shall be approved by Engineer-in-charge.

4.8.4 Cables shall have complete uncut lengths from one termination to the other.

4.8.5 All cables shall be indicated close to their termination point by cable number as per cable schedules/junction boxes schedules. PVC ferrule/tag plate shall be used and these identification tags shall be securely fastened to the cables.

4.8.6 All temporary ends of cables shall be protected against dirt and moisture. For this purpose, ends of all cables shall be taped with an approved PVC or rubber insulating tape or end caps.

4.8.7 All cores of electrical cables shall be identified by their wire numbers by means of the PVC ferrules. Wire numbers shall be as per cable schedules and control room termination drawings. The terminal numbers shall be screen printed on single ferrule to identify the source and or destination as per the instruction of Engineer-in-charge.

4.8.8 The cores shall be terminated at the termination points using proper lugs. However, lugs shall not be used for compensating cables.

4.8.9 The bending radius of cables shall be maintained as per manufacturers' recommendation.

Cables installed above ground shall be run exposed on walls, ceilings, structures and shall run parallel or at right angles with beams, walls or columns.
4.8.10 Cables shall be rigidly supported on structural steel and masonry individually or in groups as required using PVC covered galvanised clips, multiple cable supports or cable trays. If drilling of steel must be resorted to, approval must be obtained and steel must be drilled where the minimum weakening of the structured wall results. Cable shall be supported at every 500 mm on vertical runs and every 100 mm on horizontal runs.

4.8.11 All special cables and power supply cables shall be laid direct to the field instrument without any junction boxes, unless otherwise specified.

4.8.12 While laying cables in ducts/trenches or burying them, care shall be taken to ensure that low signal cables like alarm, analyser cables, special cables from turbine meters, compensating cable etc. are separated from other power supply cables.

4.8.13 Each underground cable (either in concrete trenches or buried) shall be provided with identifying tag of lead securely fastened every 30 m of its underground length with at least one tag at each end before the cable leaves/enters the ground.

4.8.14 Directly buried cables shall be laid underground in excavated cable trench wherever specified in layout drawings. Trenches shall have sufficient depth and width to accommodate all cables correctly spaced. Pipe sleeves, if required, for cross overs other than roads like drains etc. shall be provided by the contractor as per the instructions of Engineer-in-charge. Before cables are placed, the trench bottom shall be filled with 100 mm layer of sand and leveled.

Each layer of cables shall be covered with 150 mm of sand on top and sand shall be lightly pressed. A protective covering of 75 mm thick second class red bricks shall be placed flat on the final layer of sand and cable. The remaining portion of the trench shall be then back filled with soil compacted and levelled. On completion of every group of cable laying and before sand filling, every cable shall be given insulation test in the presence of Engineer-in-charge.

Any cable proved to be defective shall be replaced before the next group of cables are laid. Cable route markers indicating number of cables, depth and direction will be placed enroute, on crossovers/turnings etc. to mark the cable route.

4.8.15 At each road crossings and other places, where cables enter pipe sleeves, adequate bed of sand shall be given so that the cables do not lack and get damaged by pipe ends after back filling. After laying, the pipe sleeves shall be sealed using sealing compounds.

4.8.16 At the entry into concrete blocks at road crossings, cable loops shall be provided at either ends to prevent any damage to cables. Each cable shall have one tag at each end before the cable enters/leaves conduit pipes.

4.8.17 After laying of all the cables and multi tubes, the cable entry to control room shall be suitably filled and sealed using sealing compound or by installing MCT including fixing of MCT Frame/blocks, routing cables, so as to achieve a positive seal against the entry of gas/water.

4.8.18 On completion of cable laying in concrete trenches, the trenches shall be filled with sand and pre-cast concrete slabs / chequered plates shall be placed on the trench.
4.9 **Earthing**

4.9.1 Earthing of instruments, analysers, junction boxes, local panels/cabinets and shelters shall be carried out as per the documents and instructions from Engineer-in-charge.

4.10 **Painting**

4.10.1 This part of the specification is applicable to cable ducts, MS cable trays, angle trays, instrument supports/perforated trays, all structural supports for the above items, etc.

4.10.2 The surface to be painted shall be thoroughly cleaned with wire brush, sand paper to remove all scales. After cleaning, the surface is painted with one coat of red oxide zinc chromate primer conforming to IS-2074 and allowed to dry completely.

4.10.3 Primer coated surface is painted with one coat of paint to the colour nearest to the final paint and allowed to dry. The colour number shall be specified by Engineer-in-charge as per IS-5.

4.10.4 Final second coating shall be with the paint of desired colours and shall also be specified by Engineer-in-charge as per IS-5.

4.10.5 It shall be noted that final second coating of external surfaces not covered by cables, copper tubes etc. shall be applied just before handing over the plant or commissioning of the plant whichever is earlier.

4.10.6 The name of manufacturer, colour and quality of all types of primer and final paint shall be subject to approval of Engineer-in-charge.

4.11 **Testing**

4.11.1 Electrical cables for signal, power supply, alarms and shutdown shall be checked for megger values and continuity before final termination and ferruling.

4.11.2 Testing shall be carried out after the installation of instrument with primary piping/tubing complete in all respects and approved by engineer-in-charge.

4.11.3 Primary piping/tubing shall be tested hydraulically or pneumatically to 1.5 or 1.1 times respectively, of the operating pressure after isolating the instruments. Flushing of piping shall be carried out as per instructions of Engineer-in-charge. Lines shall be blown after hydro-testing. All external displacement/float type level instruments and level gauges shall also be tested as per instructions of Engineer-in-charge.

4.11.4 Tubes and air line shall be tested with compressed air to 7 Kg/ern- up to the filter regulator.

The downstream side of the filter regulator shall be tested for 1.5 Kg/em'. The lines shall be blown with the instrument air upto the regulator for 15 minutes to remove any traces of oil, dust and moisture. All lines shall be checked with soap solution and bubbler unit for possible leak at joints. After pressurising, source shall be cut off and rate of fall in pressure shall be less than 1 PSI (Pounds per Square Inch) for each 100 ft. of copper tubing for a test period of 2 minutes as per ISA RP 7-1 'Pneumatic control circuit pressure test'.

4.11.5 All the test results shall be recorded in the approved format.
4.12 Calibration

4.12.1 All instruments shall be calibrated strictly as per manufacturer's instructions prior to installation. The scope of calibration includes all field and control room instruments of all types namely, pneumatic, electronic, electrical etc.

4.12.2 Contractor shall use his own oil free instruments air compressor for calibration purposes.

4.12.3 Conversion from one unit to another for the purpose of calibration is not allowed.

4.12.4 The procedures for calibration of different items are as outlined below. However, the detailed procedure shall be submitted to Engineer-in-charge for approval before proceeding with calibration.

4.12.5 All types of transmitters, including SMART/FIELDBUS type, shall be calibrated to the ranges specified in the respective instrument data/specification sheets using suitable test equipments/kits including the verification of the configuration parameters.

4.12.6 All pressure and differential pressure transmitters shall be calibrated to the ranges as per instrument data/specification sheets and instructions of Engineer-in-charge.

4.12.7 All thermocouple receiver instruments shall be calibrated by generating millivolt signals suitable for span and the type of thermocouple specified.

4.12.8 Receiver instruments programmed shall be calibrated and aligned using test hook-up as per instructions from manufacturer/engineer-in-charge.

4.12.9 All indicating type pressure, differential pressure and temperature switches shall be calibrated for 0%, 25%, 50%, and 100% of range. These shall be set finally at the required values indicated on the data sheet.

4.12.10 Filled type temperature instruments/temperature gauges shall be calibrated for 0%, 25%, 50%, 75% and 100% of the range using standard theromo-oil.

4.12.11 Pressure transmitters shall be calibrated at 0%, 25%, 50%, 75% and 100% and vice versa of range using dead weight tester/hydraulic pumps with master gauges/pressure calibrators.

4.12.12 DP transmitters shall be calibrated at 0%, 25%, 50%, 75% and 100% and vice versa of range using water column monometers, standard gauges or squeeze bulb type of flow calibrators.

4.12.13 Rotameter transmitters shall be calibrated by moving pointer 0%, 25%, 50%, 75%, 100% and vice versa of the range and monitoring the output at the respective flow range.

4.12.14 The external displacer type of level instruments shall be dry calibrated as per manufacturer's instructions or wet calibrated by filling the displacer chamber with water for level 0%, 25%, 50%, 75% and 100% and draining the water at IOq%, 75%, 50%, 25% and 0% of the ranges after applying suitable specific gravity corrections of the process fluid as per data sheets.

4.12.15 The internal displacer/float type level instruments shall be dry calibrated as per...
manufacturer's instruction or using calibration chamber fabricated out of steel pipes and filling the same with water after applying specific gravity corrections of process fluid as per data sheets.

4.12.16 The level switches (external cage type) shall be set by filling the cage with water to the desired alarm/trip level. While setting the switches, it shall be ensured that the micro switches do not reset for full rated travel of the float.

4.12.17 Tank level indicators shall be calibrated by manually lifting the float at 0%, 25%, 50%, 75% and 100% and vice versa of the ranges.

4.12.18 Control valves and positioners of all types (Pneumatic / SMART / Field bus) shall be checked for hysteresis and linearity and shall be calibrated for rated strokes. Prior to calibration, the valves shall be cleaned externally. The stem is then lubricated if required, and stroked few times to extreme positions of plug to ensure that movement is free from friction. The valves shall then be calibrated for rated stroke and linearity also. Subsequently the valves shall be checked for hysteresis to the accuracy of 1% full scale with Field bus / SMART / Pneumatic positioner and 5% full scale without positioners. Stroke speed has to be evaluated for trip/shutdown valves as per safety requirements identified by Engineer-in-charge.

4.12.19 All calibration readings shall be recorded in the enclosed format and submitted to engineer-incharge for approval. Where significant deviations from specifications are obtained, the matter shall be brought to the immediate notice of the Engineer-in-charge for corrective action.

4.12.20 Furnished hereunder is a list of recommended calibration and test equipments required as a minimum for calibration work. The contractor shall clearly state in his offer, the complete list of calibration and test equipments along with the range, accuracy and quantity which he proposes to use for this job. Contractor should also ensure that any equipment not listed below but required at the time of calibration shall be made available at his own cost. All the instruments are to be calibrated using the test equipments and kits approved by NPL/IDEMI/ERTL authorities or by any laboratory accredited by NABL having valid calibration report at the time of calibration. In the event, any test equipment is sent to a laboratory for enhancing validity, it shall be contractor's responsibility to arrange alternate test equipments, duly meeting the above criteria, to carry out calibration/loop checking activities.

a) Controller test stands Mfr. Standard
b) Indicator/Recorder test stands Mfr. Standard
c) Squeeze bulb (Flow calibrator) Range; 0 to -10,000 mm wg. -
d) Dead weight testers (Budenberg or equivalent for ranges upto 350 kg/em" ± 0.05 %
e) Gauge comparator for pressure gauges Rating: upto 350 kg/ern" ± 0.02 %
f) Oil bath for temperature instrument calibrations Max. temperature 350 C Mfr. Standard
g) Standard mercury in glass thermometers
   Range; -50 to +50 c., 0 to 100 c
   (NPL certified) 0-250 c.
   ± 0.25 %

h) Standard gauges for Ranges upto
   350 kg/ern²
   ± 0.1 %

i) U-tube differential manometers/inclined
   tube monometer Static Pr. rating.Zkg/cm².
   ± 1 mm

j) Single leg manometers
   Scale; -1500mm water 1500mm hg.
   Static Pr. rating: 7kg/cm²
   ± 1 mm

k) Decade resistance box
   Mfr.s Standard

l) Multimeters

m) Potentiometer/Direct digital calibrator
   (capable of generating and measuring mV)
   ± 0.05 mV

n) Meggers 500v/1000 ν
   -

o) Air hydro pump/hydraulic pump
   -

p) Vacuum pump
   -

q) Instrument air compressor with filters
   and regulators and deoilers.
   -

r) Current generator (Instrument checker)
   -

s) Field bus calibrator (Beamex Make MC5 or equivalent)

h) Safety valve test jig for sizes from %" to 10" (upto 600#)

4.13 Loop Checking

4.13.1 Loop checking shall be performed after calibration, installation, interconnection, continuity check
and leak testing of instrument impulse lines for all instruments. Loop checking is conducted to
verify the functional performance of all elements comprising the loop, thereby ensuring proper
interconnections and operation. The results of various activities completed like calibration,
installation, interconnection, loop checking and logic checking shall be recorded in the loop
checking report format, which is attached as Annexure I (4 sheets).
Any punch points observed while carrying out loop checking or activities required as prerequisite to loop checking shall be recorded in the loop checking report format attached as Annexure 2. The loop checking shall be performed only after the resolution of the punch points.

4.13.2 Before proceeding for loop checking, the calibration results of individual elements shall be separately recorded on the calibration reports and shall be approved by Engineer-in-charge for correctness of calibration results.

4.13.3 Loop checking of various types of loops shall be performed as follows, however, detailed procedure shall be submitted to the engineer-in-charge for approval before proceeding with the loop checking;

a) The loop checking of all the open loops with smart or field bus shall be performed using hand held communicator / field bus calibrator by simulating 0%, 25%, 50%, 75% and 100% of full scale input in the field. The tests shall also include the verification of tag configuration parameters e.g. ranges etc as per instrument data sheet.

However loop checking of conventional (non-SMART & non-FIELDBUS) transmitter in open loop shall be performed by physically applying 0%, 25%, 50%, 75% and 100% of process parameters as per instrument data sheet in the field.

b) The loop checking of all close loops with conventional (non-SMART & nonFIELDBUS) / SMART / Fieldbus transmitters shall be carried out by physically simulating the process conditions for at least 0%, 25%, 50%, 75% and 100% of full scale input and verifying the values in receiver instruments/operator station in the control room. Similarly, the control valves operation shall be verified by feeding 0%, 25%, 50%, 75% and 100% output from the operator stations/controllers in the control room.

c) In case of shutdown systems, field switches/receiver switches/field transmitters shall be simulated for abnormality by disconnecting the wires at terminals in case of switches and physically simulating the process for the corresponding trip point signal in case of transmitters and the function of all the associated systems are checked including performance of solenoid valves, on-off type control/shutdown valves including proper functioning of limit switches and other accessories. Adjustment of limit switches wherever necessary shall also form part of checking of the loop.

4.13.4 Performance of individual loops shall be accepted for an overall accuracy of ± 1.5%. Where deviation is found to exist more than the specified limit, contractor shall recalibrate the instruments which shall also form part of loop testing wherever required, at no extra cost.

4.13.5 After the loop test is complete, the contractor shall connect back any terminations and connections removed for loop checking.

4.13.6 A loop shall be considered as handed over only when the loop checking of that particular loop is complete in all respects and the loop checking report is completely filled in all respects, approved and accepted by Engineer-in-charge and Client. In case of loops in which certain instruments of the loops are calibrated by other agency, loop checking shall be performed in coordination with the agency involved. If a defect in the calibration of the instruments in contractor's scope is observed, same shall be rectified to the satisfaction of the Engineer-in-charge. However, if defect
is detected in the calibration of the instruments in the scope of other agency, same shall be rectified by the agency involved. After the calibration has been rechecked by other agency/agencies, the loop checking would be performed to the satisfaction of Engineer-in-charge. This is part of the contractor’s scope of work.

4.13.7 The loop checking results shall be recorded in Annexure I referred at clause 4.13.1 above.

4.13.8 Whenever the installation of central control system like Distributed Control System/Programmable Logic Controllers/Terminal automation system etc in control room is carried out by any other agency, contractor's scope of work for the loops connected to these systems shall include the following:

a) Laying of all related cables upto the designated panels/cabinets/consoles, dressing of cables including inside control room, identification of cables and cores/pairs of each cable, coordination with control system vendor during glancing and termination.

b) Calibration of all field instruments independently.

c) Providing all assistance to control system vendor during loop checking. This shall include physical simulation of signals from the field instruments through approved test equipments and checking the control valve operation with the output provided from control system to enable control system vendor to verify loop performance.

d) Coordination with control system vendor to meet loop-checking schedule. It shall be contractor's responsibility to demonstrate/prove measuring signal levels of field instrument output in control room in the respective identified pair in case of any problem.

e) Rectification/recalibration of field instruments if found defective during loop checking.

However, the glancing and termination of field cables, checking of interconnection between instrument/equipments within control room, ferruling/tagging of interconnecting cables inside control room shall all be in the scope of control system vendor.

4.13.9 It shall be contractor's responsibility to complete all entries in the 'Loop Checking Report' attached as Annexure I, related to field instrumentation and loop checking results, including calibration, installation checks, interconnection of tubing and cabling, hydrotest etc. and get it duly signed by the Engineer-in-charge. The final certified loop sheets shall be submitted in hard copies (4 sets) and soft copies (in CD) to the Engineer-in-charge.

5.0 DRAWINGS AND DOCUMENTS TO BE SUPPLIED FOR EXECUTION BY OWNER/ENGINEER-IN-CHARGE

5.1 General layout plan for all units, showing all information like location of field instruments, junction boxes, indicative routes of cables, main duct/cable trays.

5.2 Cable schedules for alarm/signal/shutdown/power supply and pneumatic tubes, earthing guidelines etc.

5.3 Termination details/drawings for connecting at control room end.
5.4 Individual instrument specifications/Data sheets.

5.5 Bill of Materials

5.6 Installation standards/hook up.

5.7 Manufacturer’s hand books with instruction for installation and calibration wherever necessary, for reverence.

6.0 DRAWINGS AND DOCUMENTS TO BE PROVIDED BY CONTRACTOR

6.1 The drawings for materials that are included in contractor’s scope of supply namely local control panel, junction boxes and local cabinets, as applicable.

6.2 The detailed engineering drawings wherever such work is assigned.

6.3 Two sets of as-built with originals consisting of instrument layout drawings, instrument index, installation standards, bill of material, cable schedules etc. duly incorporating the changes/modification carried out during the course of execution of works. The drawings/documents shall be provided by the owner for the above purpose.

6.4 Final material appropriation statement for all the free issue materials as well as materials issued on chargeable basis, indicating shortages if any, in the P erformed duly approved by Engineer-in-charge.

7.0 SCOPE OF SUPPLY FOR MATERIALS

7.1 Materials To Be Supplied By The Owner Free Of Cost-

7.1.1 All-pipes, tubes and piping materials such as fittings, steam traps, valves, flanges, gaskets, bolts- and nuts for flanges necessary for primary piping, air supply and steam tracing.

7.1.2 Tubes, tube fittings, polyethylene tubes and fittings.

7.1.3 All field mounted instruments like pneumatic, electronic and analyser instruments, pressure gauges, temperature elements, dial thermometers, thermowells, switches and accessories like air filter regulators, receiver pressure gauges, solenoid valves etc.

7.1.4 Pneumatic and electric junction boxes for field mounting.

7.1.5 Single pair/multi pair/multi triad/shielded cables/thermocouple extension cables for signal/alarm/temperature signals and any other special cable specifically indicated in Schedule of Quantities.

7.1.6 Two core/three core power cable.

7.1.7 All electrical conduits, fittings, cable glands and cable accessories unless otherwise specifically indicated.

7.1.8 Local panels.
7.2 Materials to be supplied by the contractor at his own cost, as part of this specification.

7.2.1 The procurement and supply in sequence and at the appropriate time of all materials and consumables except for the materials specifically enlisted under owner's scope of supply shall be entirely the contractor's responsibility and his rates for execution shall be inclusive for all these items. These are as, but not limited to, the following:

a) All industrial gases like oxygen, acetylene or inert gases, compressed air and all types of electrodes, filler wires, brazing rods, flux etc. for welding purpose, with necessary facilities for testing the welded joints.

b) PTFE tape and other pipe jointing compounds for threads and material for sealing of cable entries to control room, local panels, insulation tapes, sealing compounds for flame proof conduit fittings.

c) Bolts and nuts for supports, U-bolts with nuts, clamps for tubes and pipes, anchor bolts for panels, expansion bolts (pinch anchor/raw bolts) of various sizes for fixing to concrete structures.

d) Polythene bags for protection of instruments against rain.

e) Paints, primers and solvents.

f) Plastic tags for identifications of tubes/wires at panel/junction boxes.

g) All materials for minor civil works like grouting etc.

h) Structural steel, MS Plates, GI plates, flats, pipe etc. required for fabrication of instruments supports and tray supports wherever required.

i) All accessories for electrical wiring like cable lugs, ferrules for identification etc.

7.2.2 Prefabricated main cable ducts and perforated/ladder trays with necessary accessories like tees, bends, crosses etc. as specified in schedule of quantities.

7.2.3 Mounting accessories for the above like bolts, supports etc.

7.2.4 Speool pieces and blinds for testing wherever required.

7.2.5 Any other item not specified, but required for the completion of the job.

Note: The contractor shall submit in sealed cellophane packets samples of all consumables like bolts, nuts, lubricants, ferrules, lugs and any other material included in their scope of supply for approval of engineer-in-charge which then forms the standards for erection work.

8.0 SCRAP AND EXCESS MATERIAL

8.1 Every month, the contractor shall submit an account for all the materials issued to him by the owner in the standard Performa prescribed for this purpose by the engineer-in-charge.
8.2 On completion of the work, the contractor shall submit ‘material appropriation’ statements for all the materials issued by the owner in the Performa prescribed by the Engineer-in-charge.

8.3 The following scrap allowances are permissible:

<table>
<thead>
<tr>
<th>Length below 0.5 metres</th>
<th>Non salvageable</th>
<th>Unaccountable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel pipes, SS tubes</td>
<td>2%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

Length below 2.0 metres

| Single pair, Single triad, two core/ three core cables | 2% | 0.5% |

Length below 20 metres

| Multitube, Multicables | 2% | 0.5% |

8.4 All excess materials and scrap shall be returned after duly accounting for, to the storage points designated by the owner. Where materials are to be weighed before return, the contractor shall be responsible for making the necessary arrangements for weighing etc. The contractor shall not use scrap section obtained during the course of construction for fabricating temporary supports or other items without prior permission of the Engineer-in-charge.

8.5 If the contractor fails to return the surplus material as aforesaid, the owner will charge the contractor for such unreturned material at penal rates, which will be deducted from whatever amount is due to the contractor. In case any material issued by the owner deteriorates during storage by the contractor, new material will be issued to him at penal rates, but the delay in procuring such materials will be to the contractor’s account only.
ANNEXURE - I

LOOP CHECKING REPORT
LOOP CHECKING REPORT  ANNEXURE – I Sheet 1 of 4
LOOP CHECKING REPORT ANNEXURE – I Sheet 2 of 4
# Field Bus Instruments Testing Results

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Test Input</th>
<th>Resistance Measurement</th>
<th>Capacitance Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Expected</td>
<td>Actual</td>
</tr>
<tr>
<td>1a</td>
<td>(+) to (-) signal</td>
<td>&gt; 50 kΩ</td>
<td></td>
</tr>
<tr>
<td>1b</td>
<td>(+) to shield</td>
<td>&gt; 20 MΩ</td>
<td></td>
</tr>
<tr>
<td>1c</td>
<td>(-) to shield</td>
<td>&gt; 20 MΩ</td>
<td></td>
</tr>
<tr>
<td>1d</td>
<td>(+) to ground bar</td>
<td>&gt; 20 MΩ</td>
<td></td>
</tr>
<tr>
<td>1e</td>
<td>(-) to ground bar</td>
<td>&gt; 20 MΩ</td>
<td></td>
</tr>
<tr>
<td>1f</td>
<td>Shield to ground bar</td>
<td>&gt; 20 MΩ</td>
<td></td>
</tr>
</tbody>
</table>

**Type of Power Supply:**
- **FISCO □**
- **FINICO □**
- **Field Barrier □**

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Measurement Location</th>
<th>DC Voltage Measurement (in DC Volts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>FISCO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expected</td>
</tr>
<tr>
<td>2a</td>
<td>Power supply conditioner voltage input, (+) to (-) signal</td>
<td>12.4</td>
</tr>
<tr>
<td>2b</td>
<td>Power supply conditioner field side output, (+) to (-) signal</td>
<td>20~30</td>
</tr>
<tr>
<td>2c</td>
<td>Field barrier input, (+) to (-) signal</td>
<td>-</td>
</tr>
<tr>
<td>2d</td>
<td>Field barrier output, (+) to (-) signal</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Measurement Location</th>
<th>Signal Level Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a</td>
<td>At Marshalling end(*), signal level from FB Monitor, (+) to (-) signal</td>
<td>350 to 700</td>
</tr>
<tr>
<td>3b</td>
<td>At Field end(**), Signal level from FB Monitor, (+) to (-) signal</td>
<td>350 to 700</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Measurement Location</th>
<th>Noise Level Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>4a</td>
<td>At Marshalling end(*), Noise level from FB Monitor, (+) to (-) signal</td>
<td>&lt; 25</td>
</tr>
<tr>
<td>4b</td>
<td>At Field end(**), Noise level from FB Monitor, (+) to (-) signal</td>
<td>&lt; 25</td>
</tr>
</tbody>
</table>

(*) At Marshalling end means power supply conditioner output to H1 module.
(**) At Field end means power supply conditioner output to field.
### Loop Checking Report

<table>
<thead>
<tr>
<th>Loop No:</th>
<th>TAG No.</th>
<th>Type:</th>
<th>BL 1</th>
<th>Input</th>
<th>Transmitter Output</th>
<th>Indicator Reading</th>
<th>DCS Reading</th>
<th>Controller Output (%)</th>
<th>BL 2</th>
<th>Type:</th>
<th>Input</th>
<th>Positioner Output</th>
<th>Control Valve Lift</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

### Additional Information

- **Notes:**
  - Block No: BL1, BL2, BL3, BL4, BL5, BL6
  - Contractor: System Vendor
  - Client: 

---

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LOOP CHECKING REPORT   ANNEXURE – I Sheet 4 of 4
## Logic Checking Report

**Interlock No:**

<table>
<thead>
<tr>
<th>Logic Input (Tag No)</th>
<th>Type (Transmitter/Switch)</th>
<th>Calibrated Set Point for Trip</th>
<th>ESD/Off Valve/Control Valve</th>
<th>MCC Output</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Logic Verification In:** DCS  FLG

**Tags No**

<table>
<thead>
<tr>
<th>TAG NO</th>
<th>ACTION</th>
<th>TAG NO</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Form No:** 02-0000-0021F2 Rev1

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LOOP CHECK / LOGIC CHECK PUNCH POINTS ANNEXURE- II
### (A) CALIBRATION RESULTS PUNCH POINT

<table>
<thead>
<tr>
<th>SL NO</th>
<th>LOOP NO/TAG NO</th>
<th>PUNCH POINT</th>
<th>ACTION REQUIRED</th>
<th>BY</th>
</tr>
</thead>
</table>

**CONTRACTOR:**

**PME:**

**CLIENT:**

### (B) INSTALLATION CHECK PUNCH POINTS:

<table>
<thead>
<tr>
<th>SL NO</th>
<th>LOOP NO/TAG NO</th>
<th>PUNCH POINT</th>
<th>ACTION REQUIRED</th>
<th>BY</th>
</tr>
</thead>
</table>

**CONTRACTOR:**

**PME:**

**CLIENT:**

### (C) LOOP CHECKING PUNCH POINTS:

<table>
<thead>
<tr>
<th>SL NO</th>
<th>LOOP NO</th>
<th>PUNCH POINT</th>
<th>ACTION REQUIRED</th>
<th>BY</th>
</tr>
</thead>
</table>

**CONTRACTOR:**

**SYSTEM VENDOR:**

**PME:**

**CLIENT:**

### (D) LOOP CHECK PUNCH POINTS:

<table>
<thead>
<tr>
<th>SL NO</th>
<th>LOOP NO</th>
<th>PUNCH POINT</th>
<th>ACTION REQUIRED</th>
<th>BY</th>
</tr>
</thead>
</table>

**CONTRACTOR:**

**SYSTEM VENDOR:**

**PME:**

**CLIENT:**
STANDARD SPECIFICATION

FOR

PACKAGE UNITS
Abbreviations:

AARH  Arithmetic Average Root Height
ASTM  American Society for Testing Materials
BIS    Bureau of Indian Society
DCS    Distributed Control System
DPDT   Double Pole Double Throw
IEC    International Electro-technical Commission
IS     Indian Standards
IU     Interface Unit
MAWP   Maximum Allowable Working Pressure
NPT    National Pipe Threads
SPDT   Single Pole Double Throw
CONTENTS

1. PART I  GENERAL SPECIFICATIONS OF INSTRUMENTATION

2. PART II  SPECIFICATIONS FOR MATERIAL, INSTALLATION, TESTING AND COMMISSIONING.
PART I

GENERAL SPECIFICATION OF

INSTRUMENTATION
CONTENTS

1.0 GENERAL

2.0 DESIGN PHILOSOPHY

3.0 SPARES PHILOSOPHY

4.0 SPECIFICATIONS OF INSTRUMENTS

5.0 DISTRIBUTED CONTROL SYSTEM

6.0 PROGRAMMABLE LOGIC CONTROLLER

7.0 LIST OF DOCUMENTS ATTACHED
1.0 GENERAL

1.1 Scope

1.1.1 This specification together with the attachments covers the design and engineering of instruments and control systems, complete with all accessories and materials, along with special test equipments, where the supply of such instruments or systems is part of a package being supplied by bidder. This specification is general and all instruments/systems included may not be required for the package in question. Only the portion related to the instruments/systems included in the scope of supply of packager for a particular package.

1.1.2 The detailed scope of work, specific job requirements, exclusions, deviations, additions etc. if any, will be indicated in the material requisition, equipment or plant specifications and addendum to this specification.

1.1.3 This specification provides only the qualitative specifications of commonly used instruments. Instruments not covered in this specification shall be submitted by the bidder for approval.

1.1.4 Vendor shall be fully responsible for design, material selection, sizing and selection of the proper instruments for their system. The compliance to this specification does not absolve the vendor of the responsibility towards contractual obligations with regards to completeness, proper selection, satisfactory operation and easy maintenance of the unit.

1.1.5 All equipments supplied shall be of field proven quality both with respect to design and materials. Prototype instruments or instruments of an experimental nature shall not be offered or supplied.

All instruments and control systems (Programmable Logic Controller (PLC), Distributed Control System (DCS), Analyser systems etc.) and system oriented items like machine monitoring system, Speed governor control, Antisurge / Performance control system, Analyser system etc. offered by vendor shall have a well proven performance record of operating satisfactorily in a similar unit or in an hydro carbon processing industry for a minimum of 4000 running hours.

No instrument requiring special maintenance or operating facilities shall be offered or supplied as far as possible.

1.1.6 In the event of any conflict between this specifications, data sheets, related standards, codes etc., the vendor shall refer the matter to the purchaser for clarification and only after obtaining the same should proceed with the manufacture/engineering of the item in question.

1.2 Bids

1.2.1 Vendor shall clearly define the operational philosophy proposed by them, which shall be in line with requirements specified in the job specifications. Vendor shall also clearly indicate the provision of control panels and control systems required for their package along with their offer.

1.2.2 Vendor shall furnish complete process data and operation displays to the purchaser for those instruments, and control systems which do not form part of vendor’s scope of supply but are an integral part of the control of the package.
1.2.3 Bidder shall provide the following information along with their offer.
   a) Complete scope of work.
   b) Utility requirements including Power consumption and Instrument air supply consumption. The offer shall indicate the power requirement for Uninterrupted Power Supply (UPS), Non-UPS and DC power clearly indicating the locations for each.
   c) Estimated heat load for the equipment located in control room.
   d) Control room size and layout (Tentative)
   e) Compliance to specifications and list of deviations, if any, from purchasers specifications clause number wise with reasons thereof, wherever applicable.

1.2.4 Documents like Instrument list and typical specifications and any other details if supplied by vendor in their bid, shall be retained for records only. All such details shall be submitted only after the finalisation of P&ID (Piping and Instrument Diagram). No implication shall be admissible on the basis of these documents.

1.2.5 Bidder shall enclose catalogues giving detailed technical specifications and other information for Control system and other special instruments.

1.2.6 Bidder's offer, catalogues, drawings, instrument manuals etc. shall be in English.

1.2.7 In addition to mandatory spares and consumable spares indicated elsewhere in this specification, bidder shall also quote for two years operational spares for the complete instrument and control system package offered.

1.3 Applicable national/international standards.

1.3.1 Design and terminology shall comply, as a minimum, with the latest edition prior to the date of purchaser's enquiry of following codes, standard practices and publications:

- AGA American Gas Association, Gas Measurement Committee
  - Report No. 3 - National Gas Fluid Measurement- Orifice Metering of Natural Gas.
- AG181 Foundation Fieldbus system engineering guidelines
- ANSI/ASME American National Standards Institute/ American Society of Mechanical Engineers.
  B 1.20.1 Pipe Threads.
  B 16.5 Steel Pipe Flanges and Flanged Fittings.
  B 16.47-B Large diameter Steel Flanges
  B 16.20 Ring Joint Gaskets and Grooves for Steel Pipe Flanges.
- ANSI/FCI American National Standards Institute/Fluid Controls Institute
70.2 Control valve seat leakage classification.

API American Petroleum Institute

RP 520 Sizing, selection and installation of pressure relieving system in refineries.

- Part-I -Sizing and selection
- Part-II -Installation

RP 521 Guide for pressure relieving and depressurising systems.
RP 526 Flanged steel safety relief valves.
RP 527 Seat tightness of pressure relief valves.

MPMS Manual of Petroleum measurement standards.


- Part 1 -Process Control and Instrumentation.

RP 552 Transmission Systems
RP 554 Process Instrumentation and Control
RP 555 Process Analysers

S 1101 Measurement of Petroleum liquid hydrocarbon by Positive Displacement meter.

S 2000 Venting Atmospheric and low pressure storage tank.
S 2534 Measurement of liquid hydrocarbons by turbine meter systems.

ASME American Society of Mechanical Engineers.
- Boiler and Pressure codes (Section I and VIII)-“Unfired Pressure Vessels”.

ASME PTC 19.3 Performance Test Code – Temperature measurement

ASTM American Society for Tests and Materials.

BS British Standards
BS-1042 Measurement of fluid flow in closed conduits.
BS-5308 Part-II Specification for PVC insulated cables.
BS-7244 Breather Valves.

DIN-43760 Temperature Vs Resistance curves for RTDs.
DIN-19234  Electrical Distance Sensors; DC interface for Distance Sensor and Signal Convertor.

DIN-50049  Document on Material testing.

IBR        Indian Boiler Regulations.

IEC        International Electrotechnical Commission.

IEC 60079  Electrical Apparatus for Explosive Gas atmosphere.

IEC 60085  Thermal Evaluation and Classification of Electrical Insulation.

IEC-60332  Test on bunched wires or cables.

IEC 60529  Classification of degree of protection provided by enclosures.

IEC 60534-2 Industrial Process Control Valves-Flow capacity.

IEC 60584-2 Thermocouples – Tolerances

IEC 60751  Industrial Platinum Resistance Thermometer Sensors.

IEC 61285  Industrial Process Control Safety of Analyser Houses.

IEC 61000-4 Electromagnetic compatibility for Industrial Process measurement and Control equipment.

IEC 61158  Foundation Fieldbus Specifications

IEC 61804-3 Functional blocks for process control – part 3 Electronic Device Description Language (EDDL)

IS         Indian Standard

IS-5       Colours for ready mixed paints.

IS-319     Specification for free cutting Brass bars, rods and sections

IS-1239    Mild steel tubes, tubulars and other wrought steel fittings.

IS-1271    Specification of Thermal Evaluation and Classification Of Electrical Insulation.

IS-1554    PVC insulated (heavy duty) electric cables-working Part I voltage upto and including 1100V.

IS-2074    Ready mixed paints, air drying, red oxide- zinc chrome.

IS-2147    Degree of Protection provided by enclosures for low voltage switchgear and control gear.

IS-2148    Flame proof enclosures for electrical apparatus.

IS-3624    Specification for pressure and vacuum gauges
1.4 Drawing and Data

1.4.1 Detailed drawings, data and catalogues required from the Bidder are indicated by the purchaser in Vendor data requirement sheets. The required number of soft copies and hard copies should be dispatched to the address mentioned, adhering to the time limits indicated.

1.4.2 Bidder shall furnish all documents in A4 Size (210mm x 297 mm) paper or folded in A4 size unless otherwise specified. All drawings and sketches shall be in multiples of A4 size like A3 (297 mm x 420 mm) or A2 (420 mm x 594 mm) etc., but folded to 'A4' size. Final documentation shall be submitted in bound volumes. The soft copies of final documentation shall be submitted in 2 sets of DVDs.

1.4.3 The minimum requirements expected from the various documents listed in Vendor Data Requirement attached as 'Annexure I' to this specifications, shall be as follows:

1.4.3.1 Drawing and Document Schedule

This document lists out all drawings and documents prepared and/or submitted by vendor to purchaser either during engineering or as a part of final documentation. Following information shall be available in this document:
a) Name and number of each drawing and document listed.

b) Expected and Actual date of submission to purchaser.

1.4.3.2 Instrument Index

Instrument Index lists out all instruments appearing on the P&ID without any exception. It is a basic instrument document which is necessary for the smooth execution of a job and is also a reference document after the completion of job. Instrument Index shall be prepared in Excel.

1.4.3.3 Sub Vendor List (for Instruments and Accessories)

This document shall list all instrument items and accessories including control system along with the name of the sub-vendors from whom Bidder is likely to procure these items. Sub-vendors suggested shall be manufacturer of repute and shall be as per suggested subvendor list enclosed with the bid document.

1.4.3.4 Instrument sizing calculations

Instrument sizing calculations provide information regarding sizing (as per standards specified elsewhere in this document), type, selection and other related information.

Following sizing calculations shall be applicable, in general, duly approved by the authority indicated in Vendor's Standard Quality Plan;

a) Control valve including noise and velocity.

b) Safety valves/pressure relief valves/pilot operated pressure relief valves/rupture disc.

c) Flow element including orifice plates, averaging pitot tubes, venturi, flow nozzle etc.

d) Utility consumption calculation including power supply (UPS/Non UPS), Instrument air, steam for tracing etc.

e) Cable sizing calculations for Power cables.

f) Intrinsically safe loop calculation for proper selection considering various entity parameters.

g) Calculations for no of instruments in a segment.

1.4.3.5 Utility Requirements

This document lists out the following information regarding utilities required by the Bidder;

a) List of utilities required i.e. Power (UPS, Non UPS), Instrument air, Cooling water, steam for tracing, Nitrogen etc.

b) Location and estimated/actual requirement at each location. The requirement shall be listed as minimum/normal/maximum.

c) Incase of AC power, the In-rush current with duration and power factor shall also be indicated for each location.
1.4.3.6 Nozzle Elevation for Level Instruments

Nozzle elevation for level Instruments represent the nozzle elevation, nozzle sizes and rating, requirement of stand-pipes, type of level instrument etc. for all the vessels, columns, exchangers and tanks.

1.4.3.7 Purchase Requisition (PR)

Purchase Requisition shall contain following information as a minimum but updated in line with the finally accepted offer of the successful bidder including:-

a) Instrument specifications including detailed instrument data sheet and special requirements, if any.

b) Testing and Inspection requirements

c) Vendor data requirements

d) Other related documents like Standard Specifications, Quality Assurance requirements etc.

1.4.3.8 Functional Schematics

Functional Schematics details out the functionality of all the loops shown on the P&ID including their co-relation. The schematic shows all the hardware necessary to configure a loop including their physical location, their interconnection and important software blocks as applicable to make a loop complete. Similar loops may be combined under the same functional schematic.

1.4.3.9 Logic Diagrams

Logic diagram is a logic representation of process interlock and shutdown system and details out the functionality, in a schematic form, as either process cause and effect table shown on the P&ID or in a separate write-up. The schematic shall be prepared based on ISA S5.2 – A Binary Logic Diagrams for Process Operations@ and shall show the physical location of Input/output devices, their interconnection with functional blocks, bench status of all electrical devices etc. The schematic shall also be supplemented with operational requirements like startup and process bypasses, reset and shut down push buttons, selector switches, status lamp etc.

1.4.3.10 Segment Drawing

The FF segment drawing provides the complete segment design details indicating all the devices of a segment, the Tag names, device control/monitoring functional requirements, spur length, FF Junction box barriers connectivity, termination details, location of JB etc. 1.4.3.11 Instrument Loop drawings Each loop shall have a separate Instrument Loop drawing which shall show each component from field device to final receiver including physical location; initiating device, its terminal number; junction box with its terminal number; cable number with pair number/polarity; receiver instrument terminals/cabinet terminals; system functional blocks of loop in simplified manner (without configuration details).

1.4.3.12 Control Room Layout

Control room layout drawing shall show the location of control panels, system cabinets, marshalling racks and other auxiliary cabinets, consoles with monitors, hard wired consoles,
printers, non-system panels/cabinets including panels/cabinets for packages, LEL panel, fire alarms panels or any other equipment required to be installed in control room. The layout shall be prepared on control room architectural drawing and shall also show layout of equipment in engineering room/computer room etc.

1.4.3.13 Panel Front Arrangement

This drawing shall show the arrangement of Panel mounted instruments like indicating instruments, alarm annunciator, indicating lamps, push buttons/switches etc. including their approximate sizes and their mounting locations.

1.4.3.14 Configuration Diagram

This drawing is a graphical representation of all major hardwares required in a configurable control system which are necessary to meet all the expected functional requirements.

1.4.3.15 Dynamic Graphic Display Drawings

These drawings provide a graphic representation of P&ID's arranged in a sequence which when displayed on the VDU, shall provide easy and logical operational views.

1.4.3.16 Input/Output Assignment

This document indicates the physical assignment of various I/O modules and their respective channels to various physical inputs and outputs.

1.4.3.17 Instrument Duct/Tray/Trench Layout

Instrument duct/tray trench drawing shows the routing of main instrument duct/tray trench in the unit/plant. The drawing shall be prepared on plot-plan and shall show the size, cross-section at various locations, general notes, symbols, reference drawings and the control room entry.

1.4.3.18 Instrument Location Plans

Instrument Location Plans shall show the location of instruments, location of tapping points, location of local panels, junction boxes, main cable trenches, instrument air distribution scheme etc. These drawings are prepared on equipment layout drawings preferably in 1:50 scale.

1.4.3.19 Instrument Cable Schedule

The instrument cable schedule shall show all instrument and power cables required for complete instrumentation. The document shall show tag number, cable number, type, length and size of cables, type of junction box, identity of local panel, control room panel/cabinet location etc. The cable schedule document shall include all single & multi pair cables indicating terminations of instruments, field junction boxes and respective termination in satellite rack room cabinets. The instrument cable schedule shall be prepared on format No. 1651-594, 595, 596 and 1851.

2.0 DESIGN PHILOSOPHY

2.1 Instrumentation shall be complete in every respect and liberal to the extent of providing data on all operations and variables sufficient for the safe, efficient and easy operation, start up and shut down of the plant.
2.2 The design and installation of instruments shall be generally in accordance with ISA/API recommended practices and other applicable standards like BIS, IBR etc. Material specifications and practices shall, in general, conform to appropriate ASTM or equivalent standards. All standards and code of practices referred to herein shall be of the latest edition prior to the date of purchaser's enquiry.

2.3 All instruments and equipments shall be suitable for use in a hot, humid and tropical industrial climate in which corrosive gases and/or chemicals may be present. As a minimum, all instruments and enclosures in field shall be metallic construction, dust proof and weatherproof to IP-55 as per IEC-60529/IS-13947 and secure against the ingress of fumes, dampness, insects and vermin. All external surfaces shall be suitably treated to provide protection against corrosive plant atmosphere.

2.4 The design of electronic instruments shall be in compliance with the electromagnetic compatibility requirements as per IEC 801 'Electromagnetic compatibility for Industrial Process measurement and Control equipment.

2.5 Instrument Requirements for classified area:

   a) All electronic/electrical instruments and equipments shall be suitable for area classification as per IEC codes and shall be tested by any recognised authority like BASEEFA, FM, PTB, CMRI etc. and shall be certified by Petroleum And Explosives Safety Organisation (PESO)/ Chief Controller of Explosives (CCE), Nagpur or Director General of Mines Safety (DGMS) in India.

   b) Certified Intrinsically Safe (IS) equipment as per IEC-60079-11 shall be used, in general, in hazardous area, for conventional loops.

   c) Field instruments in fieldbus loops shall be designed and FISCO certified with FISCO marking as per IEC 60079-27 for hazardous area application. Wherever FISCO certified field instruments is not available, intrinsically safe entity based field instruments shall be used with suitable accessories to per mit IS device in FISCO installations as per AG181.

   d) In case intrinsically safe equipment is not available, flameproof enclosures as per IEC-60079.01 may be considered.

   e) Junction boxes and accessories required for flameproof instruments shall also be certified flameproof.

   f) All non flameproof panels and cabinets installed in classified area shall be purged as per requirements specified in NFPA-496, as a minimum.

   e) Other type of protection as specified in IEC-60079 shall not be used.

2.6 Statutory Approvals

   a) Contractor shall be responsible for obtaining all statutory approvals, as applicable for all instruments and control systems.

   b) In addition, equipments/instruments/systems located in the hazardous area shall be certified by the local statutory authorities for their use in the area of their installation. In general following certification shall be given:
- For all intrinsically safe/ FISCO/FINICO/ explosion proof/flameproof equipments/instruments/systems or equipments with any other type of protection allowable as per this package which are manufactured abroad and certified by any statutory authority like BASEEFA, FM, UL, PTB, LCIE etc. should also have the approval of Petroleum And Explosives Safety Organisation (PESO)/ Chief Controller of Explosives (CCE), Nagpur.

- For all flame proof equipments manufactured locally (indigenously), the testing shall be carried out by any of the approved test house like CMRI/ERTL etc. The equipment shall in addition bear the valid approval from Petroleum and Explosives Safety Organisation (PESO)/ Chief Controller of Explosives, Nagpur and a valid BIS license.

- For all intrinsically safe equipment manufactured locally (indigenously), the testing shall be carried out by any of the approved test house like CMRI/ERTL etc. The equipment shall in addition bear the valid approval from Petroleum and Explosives Safety Organisation (PESO)/ Chief Controller of Explosives, Nagpur.

c) Approvals other than above shall neither be offered nor these will be acceptable.

2.7 Following units of measurement shall be applicable, unless indicated specifically otherwise;

- Flow
  - Liquid: m³/h
  - Steam: kg/h

- Gas & Vapour: Nm³/h

- Pressure/Vacuum
  - Gauge: kg/cm²/g
  - : mm of H₂O
  - Vacuum: kg/cm²
  - : mm of H₂O

- Temperature: °C

- Level: %

- Analysis: %
  - : ppm

- Conductivity: micro Siemens

- Viscosity: mPa.s (cP)

2.8 Local control loops shall be avoided. In case these are unavoidable, these shall be electronic field mounted manual loading station only.

2.9 Ranges for instruments shall be selected in general, such that in normal process operation the indication is between 40% to 60% of span for linear and 60% to 80% of span for square root inputs.

2.10 Ranges for process switches shall be selected, in general, such that the set point falls preferably in the middle 30% of full adjustable range i.e. the set point shall fall between 35% and 65% of adjustable range.
2.11 All controllers shall have facility for bumpless auto-manual and manual-auto transfer and set point adjustment. Flow, pressure and level controller shall be provided with proportional plus integral action, while temperature controller with proportional plus integral plus derivative action.

2.12 Field mounted direct actuated Flow and Temperature switches shall not be used. Instead, receiver switch/trip amplifier shall be used along with flow element/temperature element.

2.13 Intrinsically Safe System Requirements

Following points must be considered while designing an intrinsically safe system;

a) All intrinsic safety barriers shall be active type isolating barriers only, with three port isolation is required. Zener barriers shall only be used if unavoidable. Prior approval of purchaser shall be taken in such case with justifications.

b) Barriers must be selected based on entity concept. Cable parameters shall also be considered while matching entity parameters.

c) Each instrument in the hazardous area and the intrinsic barrier shall be certified for intrinsic safety by any statutory authority.

d) Each input and output in a loop shall have separate barrier. No barrier shall be shared between two loops or input/outputs.

e) Any device required to be connected to any intrinsically safe loop in the hazardous side permanently or temporarily shall also be certified intrinsically safe.

f) Configuration tools whenever required for any intrinsically safe item, which forms part of the intrinsically safe item shall also be certified intrinsically safe.

2.14 Power Supplies and their Distribution

a) Power supply shall be made available at the following voltage levels, unless otherwise specified:

° For Instruments, Control Systems, Analyzers 110V ac ± 10% (UPS)

°(*) Solenoid Valves, Relays, lamps 110V dc ±10%

°(*) Input interrogation voltage 110V dc ±10%

° Panel/cabinets lighting 240V ac ± 10%

(*) When specified in job specification for Ex proof switches/ SOV/ Lamp/ PB Design cases.

In case 24 V dc is required for Input interrogation, relays and lamps etc same shall be generally by the bidder using dual Redundant power packs (110 V dc to 24 V dc converter). No 24 V dc feeders shall be supplied unless indicated specifically in the job specifications. refer Note 1

b) All instruments, control systems (PLC and DCS) and analyser system shall be able to operate at the following UPS specification:

Voltage level : 110V ac ± 10%

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Note 1: 24V DC Control Power supply in DCS & PLC system shall be with Mosfet O-Ring With Balanced Current. The same Shall be For reverse Polarity Protection
STANDARD SPECIFICATION FOR
PACKAGE UNITS

Frequency : 50 Hz ±3 Hz
Switch over time : 5 milli seconds.

c) Power feeders shall be supplied to the bidder at one location. All further distribution within the package shall be taken care of by the bidder. Number and size of Power feeders shall be informed during detail engineering. Vendor shall provide adequate number and size of terminals and cable glands required.

d) Instrument power circuits shall be individually protected from fault with the help of fuses. Power supply to the individual instrument shall be disconnected with the help of DPST switch and protected with the help of fuses. Miniature circuit breakers (MCB's) may be selected in place of switch fuse unit in case protection is provided for overload protection.

2.15 Alarm Philosophy

a) Adequate alarms shall be provided to give audible and visual warning of any process and machine malfunction in the package.

b) All trips shall have a pre-trip warning alarm in addition to alarm at the trip condition.

c) All package alarms including pre-trip warning alarms and trip alarms (shutdown alarms) shall be annunciated on the local panel

d) All rotating equipments shall have the status indication provided on the local panel.

e) Common pre-warning alarm and common trip alarm contacts for the package shall be provided for remote annunciation. Additional alarm contacts shall be provided when specified.

f) ‘Fail-safe’ type with normally closed alarm contacts shall be used.

2.16 All line or equipment mounted instruments like control valves, pressure relief valves, thermo-wells, orifice flanges, level instruments etc., installed on pipes and vessels under IBR shall be certified by IBR or their authorized representative.

2.17 Location of process connections shall be from the side or from the top of the process equipment but not from the bottom. This requirement is applicable to both pipes and vessels. The location of lower side connection when necessary shall be high enough to prevent plugging due to dirt or other suspended solids. In addition, the connections shall be short, vertical or horizontal and without any pockets.

2.18 Material of construction of instruments shall be as per the material selection chart, refer 'Annexure II', attached as part of this specification, as a minimum. However vendor is responsible to ensure that the selected material is consistent with temperature, pressure, corrosion conditions and other process requirements.

In case where suitable material of construction is not feasible/possible, diaphragm seal shall be considered.
2.19 All process switches shall be provided with sealed micro switch contacts rated for the specified application. Contacts shall be SPDT type unless otherwise specified. Contacts used in intrinsically safe applications shall be Alloy plated.

2.20 Field transmitters

2.20.1 The field transmitters in all conventional loops shall be smart type only unless specified otherwise. All field transmitters shall have 10 year stability.

2.20.1.1 Field transmitters for flow, pressure, differential pressure and level applications shall be yoke mounted type unless specified otherwise. Meter electronics is used for flow measurement, etc. and shall include all the associated items like pre-amplifier, converter, transmitter, integrator, integral output meter etc.

2.20.1.2 Field transmitter shall be intrinsically safe and meter electronics shall be intrinsically safe, in general. In case, intrinsically safe is not available from the approved vendor list enclosed with this MR, flameproof enclosure is acceptable. In case sensor/ pick up coil is intrinsically safe, suitable barrier shall be provided and installed in flameproof enclosure.

2.20.1.3 These transmitters shall be 2 wire system having 4 - 20 mA DC output with superimposed digital signal having simultaneous analog and digital communication with HART communication protocol, unless otherwise specified.

2.20.1.4 The transmitter shall be microprocessor based and it shall incorporate a non-volatile memory which shall store complete configuration data of transmitter and its sensor characterization. All necessary signal conversions, including conversion to produce output with the required protocol shall be carried out in the transmitter electronics. The configurationally data of the instruments shall be stored in a non-volatile memory such that this remains unchanged because of power fluctuations or power off condition. In case vendor standard instrument has battery backed RAM, contractor to ensure that battery drain alarm is provided as diagnostic maintenance message.

2.20.1.5 Transmitter shall also run complete diagnostic subroutines and shall provide diagnostic alarm messages for sensor as well as transmitter healthiness. In the event of detection failure, the output shall be driven to a predefined value, which shall be field configurable.

2.20.1.6 Universal hand held configurator / terminal for the configuration and maintenance of instruments with HART output shall be provided for all HART based smart instruments.

2.20.2 Fieldbus Field Transmitter and devices:

2.20.2.1 Fieldbus transmitters / devices shall be provided, if specified, in fieldbus loops.

2.20.2.2 Fieldbus based transmitter/ devices shall meet the following requirements;

1) All instruments must satisfy the requirements of the field bus registration laboratory with applicable checkmark of foundation field bus.

2) All instruments shall be polarity in-sensitive. Also transmitter shall have LAS capable and line plugging detection, whenever specified in data sheet.

3) All instruments shall have Analog Input (AI) block and Proportional, Integration and differential (PID) control block, as a minimum.
4) All instruments must be interoperable and shall have valid interoperability test clearance like ITK latest version for foundation field bus or equivalent for profibus PA, as applicable.

5) The field bus instruments shall support peer to peer communication with two wire communication and bus powered supply.

6) The field bus instruments in hazardous area shall be certified as per entity concept or shall be FISCO approved as per the requirements specified in the purchaser’s specification.

7) All instruments shall support to EDDL or FTD/DTM requirements, as specified in data sheets.

8) Internal software shall be configured by the vendor including the following information such as serial number, Device Tag (Tag Number) and Process description

9) All instruments shall be capable of supporting incremental Device descriptor (DD) for extra functionality and/or software revisions in device memory.

10) Fieldbus based field indicator shall be able to indicate all signals available in the fieldbus segment, selectively.

2.20.2.3 The field bus / devices provided shall be able to communicate with fieldbus communicator Fisher 375F. In case the same is not confirmed for any device, bidder shall supply suitable FF configurator.

2.20.3 Accuracy of transmitters, smart as well as field bus based shall be as follows:

<table>
<thead>
<tr>
<th>Type of Transmitter</th>
<th>Range of Transmitter</th>
<th>Accuracy for the rangeability of 1:10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>760 mm WC and above</td>
<td>Equal to or better than ±0.075%</td>
</tr>
<tr>
<td>Direct</td>
<td>Less than 760 mm WC</td>
<td>Equal to or better than ±0.15%</td>
</tr>
<tr>
<td>Diaphragm seal</td>
<td>500 mm WC and above</td>
<td>Equal to or better than ±0.25%</td>
</tr>
<tr>
<td>Diaphragm seal</td>
<td>Less than 500 mm WC</td>
<td>Equal to or better than ±0.5%</td>
</tr>
</tbody>
</table>

The accuracy is defined as the combined effect of repeatability, linearity and hysteresis.

2.20.4 Transmitter shall update the output at least 8 times a second unless otherwise specified. Unless specified otherwise in purchaser’s specification, transmitter response time shall be as follows:

a) For transmitter range of 760 mm WC and above, the response time shall be equal to or better than 500 milliseconds.

b) For transmitter range below 760mm WC, the response shall be equal to or better than 1 second.

The response time of the transmitter shall be considered as the sum of dead time and 63.2% step response time of the transmitter.
2.20.5 Unless specified otherwise, the over-range/static pressure protection of the transmitter shall be as follows:

<table>
<thead>
<tr>
<th>Range of Transmitter</th>
<th>Over range / static pressure &lt;N1&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>0&lt;Ω&lt;250 mm WC</td>
<td>Pressure Transmitter (kg/cm²)</td>
</tr>
<tr>
<td></td>
<td>Differential Pressure Transmitter (kg/cm²)</td>
</tr>
<tr>
<td>250&lt;Ω&lt;1000 mm WC</td>
<td>45</td>
</tr>
<tr>
<td>1000 &lt; Ω &lt; 5000 mm WC</td>
<td>45</td>
</tr>
<tr>
<td>5000 &lt; Ω &lt; 10000 mm WC</td>
<td>45</td>
</tr>
<tr>
<td>1 &lt; Ω &lt; 10 kg/cm²</td>
<td>52</td>
</tr>
<tr>
<td>10 &lt; Ω &lt; 100 kg/cm²</td>
<td>160</td>
</tr>
<tr>
<td>&gt; 100 kg/cm²</td>
<td>210</td>
</tr>
</tbody>
</table>

<N1> However if the Over range/ static pressure value specified above is less than the maximum/ design pressure of service conditions, offered instrument shall be suitable for the maximum/ design pressure.

2.21 Instrument Connections

2.21.1 The connections of instruments installed on vessels, tanks, standpipes and piping shall be as per following Standards.

a) STD-7-52-001 Instrument Connections on Vessels and tanks.

b) STD-7-52-002 Instrument connection on Piping.

2.21.2 Pneumatic instrument connections for signal and air supply shall be 1/4" NPT (F).

2.21.3 Electrical cable entry connection shall be 1/2" NPT (F). Suitable cable gland shall be used.

2.21.4 End connections shall meet the following, unless, otherwise specified:

a) Threaded end connection shall be NPT as per ANSI/ASME B1.20.1.

b) Flanged end connection shall be as per ANSI/ASME B16.5.

c) Flange face finish shall be per paragraphs 6.4.4.1, 6.4.4.2 and 6.4.4.3 of ANSI/ ASME B 16.5. The face finish wherever specified in data sheets shall have serrations as follows:

   125 AARH : 125 to 200 AARH

   63 AARH : 32 to 63 AARH
d) Grooves of ring type joint flanges shall be octagonal as per ANSI/ASME B 16.20 2.22
Air supply at pressure specified elsewhere shall be made available to the vendor at the battery limit for distribution to the instruments.

2.23 Interface with Main Control Room

2.23.1 Wherever applicable, instrument junction boxes shall be provided as interface. Marshalling details between purchaser -vendor tubing and cabling shall be shown with corresponding junction box termination number allocated against appropriate purchaser's/vendor's instrument tag number. Drawing shall be furnished separately for wiring and tubing for showing all instrument interface details between purchaser -vendors.

2.23.2 Direct signals from package/package skid
All signals from package/package skid to purchaser’s remote control room/MCC shall be terminated in the junctions boxes located at the battery limit. Separate junction boxes shall be used for the following type of signals:
- Intrinsically Safe Analog Inputs/Outputs (4-20mA)
- Non -intrinsically Safe Analog Inputs/Outputs (4-20 mA)
- Intrinsically Safe Thermocouple Inputs
- Intrinsically Safe RTD Inputs
- Intrinsically Safe contact Inputs
- Non Intrinsically Safe contact Inputs.
- Non Intrinsically Safe contact Outputs.
- Intrinsically safe contact Outputs.
- DCS and PLC signals shall be further segregated.

2.23.3 Repeat Signals from Package Local Panel
a) Where signals as indicated in Para 2.22.2 is less in number and do not justify separate junction boxes, all such signals may be routed via local control panel.

b) All such signals shall be terminated on separate terminal strips in the local control panel. The terminal strips shall be segregated as per Para 2.22.2.

c) Intrinsically safe barriers for all such signals, wherever required, shall be provided.

The above shall only be considered with prior approval from purchaser.

3.0 SPARES PHILOSOPHY

3.1 Mandatory Spares

Unless specified otherwise, the following mandatory spares shall be provided by bidder.

3.1.1 Predefined Mandatory Spares:
Mandatory spares shall be ware-house spares and shall be supplied as loose items. 

3.1.1.1 Higher of 10% or minimum one of each type (range, type, material) of complete instruments except control valve, safety valve, displacer, radar, servo level instruments, analyser, PLC, DCS.

3.1.1.2 For Control valve each control valve shall include one set of packing and bonnet with tag, one set of stem seal o-ring for each actuator and piston o-ring additionally for each piston actuated valve, line bolting (set of studs and nut) and set of gasket with each tag no.

3.1.2 Commissioning Spares:

Bidder shall be responsible to supply all spares which are found necessary to replace while performing pre-commissioning and commissioning activities and this includes system oriented items (Hardware / software).

3.1.3 Consumable spares:

Bidder shall supply consumable spares for six months of normal operation.

3.1.4 Engineering Spares:

3.1.4.1 For Control system installed spare module of higher of 10% or minimum one of input/output modules (including termination panels, if applicable) to enhance the system functional requirements of DCS and PLC.

3.1.4.2 For Hardwired console / Local control panel,

   a) A minimum of 20% spare windows with alarm modules shall be provided in alarm annunciator.

   b) A minimum of 20% spare status lamps / switches / pushbuttons / terminals or one no of each type, whichever is higher, shall be provided.

   c) For pneumatic panels, 10% spare instrument air header branch lines and 15% spare bulkheads and tapping points shall be provided in each panel.

   d) Control panels shall have additional spare-space as per clause 4.3.8 of this specification.

3.2 Normal Operational Spares

Vendor shall supply a list of spare parts for each instrument and system required for 2 years of continuous operation. These spares shall be quoted separately.

4.0 GENERAL SPECIFICATION OF INSTRUMENTS

4.1 Instrument Concept

4.1.1 Major instrumentation shall be electronic type SMART with final control elements as pneumatic.

4.1.2 Electronic Instruments

   a) All electronic instruments requiring separate power supply shall generally operate on 110 V 50 Hz. Instruments operating at 24 V dc shall also be acceptable.
b) Electronic transmitters shall generally be two-wire type. These shall have transmission/output signal of 4-20 mA dc and shall be capable of delivering rated current into external load of at least 600 ohms when powered with 24 V dc nominal voltage.

c) Smart transmitter, shall be used in analog output mode, unless specified otherwise in job specification.

d) All receiver instruments shall be microprocessor based and shall operate on voltage input of 0.25 to 1.25 V, 1 to 5 V, or 0 to 10 V dc, in general.

e) The design of electronic instruments shall be in compliance with the electromagnetic compatibility requirements as per IEC-61000-4.

e) Field bus instruments when specified shall be tick marked as per IEC-61158.

4.1.3 Pneumatic Instruments shall operate on air supply of 1.4 kg/cm² g and shall have transmission and output signal of 0.2 to 1.0 kg/cm² g.

4.1.4 Instrument air quality shall be as per ISA-S7.3 and free from corrosive, hazardous and toxic contaminants.

4.2 Panel Board Instruments:

4.2.1 Panel board instruments shall generally be multibin subminiature 6” x 3”, except recorders, which shall preferably be 6” x 6”. Instruments like microprocessor based recorders, temperature scanners etc., shall be as per manufacturer standards.

4.2.2 Panel board instruments shall have the following graduations, in general;

Differential Pressure flow meters 0 to 10 square root
Variable area Flow meter 1 to 10 linear
Pressure Direct Reading
Level 0 to 100 Linear
Temperature Direct Reading.

Multiplying factors for flow scales shall be specified on manufacturer's nameplate.

Recorder charts shall be dual graduated, in general, in 0 to 10 square roots and in 0 to 100 linear.

4.2.3 Subminiature recorders shall have 100 mm strip chart with chart speed of 25 mm/h. Microprocessor based recorders shall have strip chart of 250 mm approx. and chart speed of 50 mm/h with a provision to change speed at site.

4.2.4 Alarm Annunciator, shall either be solid state type or microprocessor based programmable type with plug in modules, in a cabinet with window display with back lighted incandescent lamps or cluster LED type integral power supply. For window display with back lighted incandescent lamps two numbers of incandescent lamps of minimum 5 watt each shall be provided for each window. For cluster type LED display, the number of LED’s in the cluster matrix windows shall be sufficient to provide illumination level of a last 150 lumens. The circuit shall be designed in such a
any that removal/failure of one lamp or LED from a window/cluster shall not hamper functioning of that particular window/display. The annunciator lamps shall be replaceable from the front of the enclosure panel. In general, dedicated alarm logic module shall be used for each alarm input. However, when micro processor based alarm Annunciator is offered failure of one microprocessor shall not affect more than four alarm windows.

Intrinsically safe annunciator circuit, when used, shall have power supply unit in a safe area. Annunciator alarm sequence shall be as per F3A of ISA.

The design of the alarm annunciator system shall be such that transient alarms of less than 330 milliseconds duration shall be automatically rejected.

4.3 Control Panel

4.3.1 All control panels shall be supplied in pre-tubed/pre-wired condition and shall be completely tested at manufacturer's works prior to dispatch.

4.3.2 Control panels shall be freestanding type and fabricated preferably from 3 mm thick cold rolled steel sheet. If the same is not available, 4 mm thick hot rolled steel sheet shall be used. Angle iron framework shall use a minimum section of 50 x 50 x 4 mm angle. The finish shall include sand blasting, grinding, chemical cleaning, and surface finishing by suitable filler and two coats of high-grade lacquer with wet sanding between coats. Two coats of paint in panel colour shall be given for non-glossy high stain finish. Panel face final colour can be any of the following shades as per IS -5:

- Opaline green : ISC No.- 275
- Light Admiralty Grey: ISC No.- 697
- Sky blue: ISC No.- 101

Panel rear surface, framework and mounting plates shall have a finish colour of pale cream to IS-5 ISC No.- 352 or Beige to IS-5 ISC No. -388 or white. A final coat of paint shall be given at site. Equivalent colour shade according to BS/RAL are also acceptable.

4.3.3 Control panel shall be open back type with each section of typically 2100 mm high, 1200 mm wide and 800 mm deep, when mounted inside the control room on 100 m m channel base covering wall to wall, else these shall be totally enclosed cubicule type. The panel width may be increased if necessary.

4.3.4 Enclosed cubicule panels shall have removable hinged doors, generally at the side or back for easy maintenance and accessibility of the instruments. Doors shall be double leaved type with handle and shall be provided with lock and key. Adequate illumination shall be provided inside the panel. All light fittings shall be suitable for 230 V, 50 Hz ac.

4.3.5 No process fluid of any kind, except instrument air shall enter the control panel. Also power supply greater than 230 V shall not enter the local panel.

4.3.6 All cable entries to the local panel shall be from panel bottom only using cable glands of adequate size. Cable gland plate thickness shall be a minimum of 3 mm cold rolled cold annealed (CRCA) as a minimum. All unused cable entries must be plugged.

4.3.7 Space heater shall be provided where condensation is expected. The space heater provided shall be with space heater with temperature cut off and manual control.
4.3.8 The design of control panel shall incorporate provision for expansion by installing adequate spare capacity. Each panel shall be designed to accommodate the following additional equipment, as a minimum

   a) 20% of panel front/inside mounted instruments including lamps, push buttons, switches, relays etc.
   b) 20% additional power feeders each provided with switch fuse assembly.
   c) 20% additional spare windows in alarm annunciators.
   d) 20% spare cable entry points.

4.3.9 Panel layout shall be designed considering ease of operation. No push button or hand switch shall be located below 600 mm. Instrument Mounting heights, in general, shall be as follows:

   a) Miniature and subminiature instruments (3 rows) Bottom row 1100 mm
      Top row 1600 mm
   b) Annunciators - 1950 mm
   c) Electric push buttons/ Switches, lamps etc.
      - 700 mm

4.3.10 The internal panel layout shall be designed considering proper approach for instruments, terminals and other accessories for maintenance, easy removal and on-line calibration. No instrument, terminals, power distribution box etc shall be mounted on the panel side plates inside the panel.

4.3.11 All lamps, status as well as alarm, shall be provided with lamp test facility. One single lamp test push button shall be used for each panel.

4.3.12 Colour Scheme

   a) Status Lamps
      On/Open/Permissive : Green
      Off/Close/Emergency : Red
   b) Alarms
      Normal/Pre-trip alarms : White
      Shutdown alarms : Red
   c) Push/Pull buttons
      On/Open : Green
      Off/Close : Red
      Emergency shut-down (ESD) : Red
      (Push-button with cover/
      Mushroom push button)
4.3.13  Panel Piping and Tubing

4.3.13.1  The instrument air header shall be adequately sized with 1/2" branches, with brass packless isolation valves and shall be complete with suitable dual filter-cum-air reducing station.

4.3.13.2  Panel tubing from the bulk head to the panel instruments and instrument air supply to the panel instruments shall be of 6 mm x 0.038" SS 316L tubing.

4.3.13.3  The tubing shall be laid in plastic slotted ducts. Panel air header and tube fittings shall be of brass, suitably protected against corrosion.

4.3.13.4  Shut off valves shall be installed in all branch lines taking off the transmission and output signal. Each tube shall be identified at both the terminating ends.

4.3.14  Panel Wiring

4.3.14.1  Open terminals shall generally be avoided. Terminal strips shall be of Phoenix / Klippon/ Elmex or equivalent type and shall preferably be mounted in an enclosure. Fused terminal may be used wherever necessary.

4.3.14.2  A minimum of 1 mm² multi stranded PVC insulated copper conductor shall be used in general. All wiring shall be laid in the PVC troughs. No trough shall be more than 70% full.

4.3.14.3  Wires carrying measurement signals associated with thermocouples, resistance thermometers, pH instruments and other low level signals shall be routed in separate troughs/wire ways and not alongside power cables. Power wiring and control wiring shall be separated by not less than 150 mm. The crossing, if unavoidable, shall be as close to right angles as possible.

4.3.14.4  Compensating cables/wires shall be used for all thermocouple inputs. These wires shall be routed in separate troughs/wire-ways.

4.3.14.5  All intrinsically safe wires shall be routed in separate wire ways from non-intrinsically safe and power wiring. Intrinsically safe wiring and terminals shall be light blue in colour and shall be separated from non-intrinsically safe terminals atleast by 50 mm.

4.3.14.6  All incoming power feeders shall be terminated on separate terminals suitable for the incoming feeder size. These shall be located at the bottom of the panel and shall be suitably covered for protection against accidental shorting and for human safety.

4.3.14.7  Following design philosophy shall be followed while deciding the internal layout of panels, as a minimum;

   a) Distance between terminal strip and side of the panel upto 50 terminals : 100 mm (min.)+ trough width

   b) Distance between two adjacent terminal strips : 100mm (min.)+trough width

   c) Distance between gland plate and bottom of the strip : 300mm (min.)

   d) Distance of terminal strip from instrument/trough/panel top : 100mm (min.)
4.4 Local Control Panel

4.4.1 Local control panel for the package units shall be installed within the battery limit of the package considering operational and maintenance requirements and accessibility. In case of skid mounted packages, panel shall be located away from the skid. In case local control panel is housed outdoor i.e. not in a local control room, it shall be designed to meet IP-55 requirements. In addition, panel must be provided with a rain cum sun shade canopy/shed.

4.4.2 Local control panel/panels shall be totally enclosed cubicles. Panel sizing shall be carried out based on equipment being installed keeping in view the maintenance clearances and easiness. Although the panel dimensions shall be guided by the actual requirements, typical dimensions of 2100 mm operational (height) x 1200 mm (width) x 1000 mm (depth) shall be kept in mind while finalizing the panel size. In any case, vendor shall not proceed with panel manufacturing before getting prior approval from the purchaser.

4.4.3 Local control panels located in the hazardous area shall either be purged type or flame proof Ex’d’ as specified in job specification. In case pressurized panels are specified the same shall be purged and pressurized as pr NFPA 496 requirements to render space within the panel non hazardous. For panels located in IEC Zone 2, hazardous area type Z purging shall be used with a purge fail alarm in main control room. In case, panels are located in Zone 1, the power shall be cut off on pressurisation on as per x-purse requirements of N FPA-426. An alarm shall be provided on local panel and a contact shall be provided for remote annunciation, whenever the panel pressurization falls below 2.5 mm of H2O. A protective device to protect the panel from over pressure must be provided.

4.4.4 Panel pressurisation with start-up panel purging scheme shall be fully automatic however it shall be started manually from a push button. Solenoid valves and differential pressure switch required for panel purging shall be flameproof, however other items like relays, switches/pushbuttons, timers etc. shall be located in a flameproof housing. Other items like valves, restriction orifice plates, dual filter regulators, pressure gauges, rotameters etc required for pressurization shall also be located in the non-pressurized section of the panel 4.4.5 It shall be possible to switch off incoming power to panel from panel front. All such power on/off switches shall be flameproof type. In addition, all those devices and terminals, which can't be powered off from on/off switches shall also be located inside flameproof enclosures.

4.4.6 All hinges, screws and other non-painted metallic parts shall be of stainless steel material.

4.4.7 All other requirements as specified in clause 4.3 of this specification shall also be applicable for local control panels.

4.5 Local Gauge Board

4.5.1 Local gauge board shall be used to install skid mounted instruments like pressure gauges, temperature gauges, process switch and transmitters.

4.5.2 Location of local gauge boards, when provided, shall be decided to allow easy access at the rear and front for all instruments and accessories for maintenance and operation.

4.5.3 Gauge board shall be constructed from 3 mm cold rolled cold annealed steel sheet with other necessary steel supporting structure and shall be painted sky blue shade No. ISC-101 as per IS-5.
4.5.4 Local gauge board shall be supplied with all instruments installed and completely in tubed/wired condition before shipment.

4.5.5 All pressure gauges shall be provided with block and bleed valves securely fastened. Identification tags shall be securely fastened for easy identification.

4.6 Temperature Instruments

4.6.1 Thermowells

a) All temperature elements shall be provided with Thermowells fabricated out of bar stock of minimum SS 304 material as per Standard STD-7-52-35. The base of the thermowells shall be chosen to fit the instrument without air gap for minimizing measuring lag.

b) Built-up thermowells shall be used in low pressure and low velocity services like in fired heaters and also where thermowell immersion lengths greater than 500 m are required.

c) Immersion length of thermowells shall be as follows:

<table>
<thead>
<tr>
<th>Line Size</th>
<th>Immersion length</th>
</tr>
</thead>
<tbody>
<tr>
<td>From 4&quot; to 6&quot;</td>
<td>280 mm</td>
</tr>
<tr>
<td>From 8&quot; onwards</td>
<td>320 mm</td>
</tr>
<tr>
<td>Vessels / columns</td>
<td>400 mm</td>
</tr>
</tbody>
</table>

In special applications, not covered above, vendor shall decide the immersion length based on actual requirements. Immersion length is based on 200 mm length between flange face and inner wall of pipe.

d) Any pipe line less than 4" nominal bore shall be blown to 4" size to install thermowell.

e) Thermowell flange and well material shall be as per material selection chart.

f) The vibration analysis shall be carried out as per ASTM PTC 19.3 and corrective measures shall be taken as necessary.

4.6.2 Temperature Gauges

a) Local temperature gauges shall be in general bimetallic type. The temperature bulb shall be of stainless steel construction. The gauge connection shall be all angles adjustable. Gas filled type shall be used when thermowell length exceeds 550 mm, Mercury filled type temperature gauge shall not be used.

b) All local temperature gauges shall have 150 mm dial size. The bulb size shall be selected to suit the thermowell.

c) All gauges shall be of weatherproof construction to IP 55 as a minimum.

d) Temperature gauges shall have accuracy of "1% URV (upper range value).

e) Bimetallic type dial thermometers shall be avoided where excessive vibrations are encountered, such as compressors. Only filled type with capillary extension shall be
used in such cases. Capillary tubing shall be minimum of 304SS with stainless steel flexible armouring, and PVC covering over armour. Filled type gauges shall be manufactured as per relevant SAMA class.

f) Thermometer stem adjustable gland with union connection and bushing shall be suitable for 1/2" NPTF connection.

4.6.3 Temperature Elements

a) For remote temperature indication/recording/control/switch etc., thermocouples or resistance temperature detector (RTD) shall be used depending on the process requirements. Elements shall be spring loaded, mineral insulated and shall have stainless steel sheath as a minimum.

b) Thermocouple assemblies shall be furnished with weatherproof screw type heads as per Standard STD-7-52-36.

c) Thermocouples shall be as per IEC-60-584-2/IS -7358 and shall have a wire size of 18 AWG for single and 20 A WG for duplex thermocouples. These shall be magnesium oxide (MgO) filled grounded type, unless necessary otherwise. The type of thermocouple shall be selected based on temperature. The selection of type shall be as per following guidelines:

Copper-Constantan (ISA-Type-T) : (-) 200 to 200°C
Chromel-Constantan (ISA-Type-E) : (-) 200 to 600°C
Iron- Constantan (ISA-Type-J) : 0 to 600°C
Chromel-Alumel (ISA-Type-K) : 600 to 1200°C
Platinum Rhodium-Platinum (ISA Type-S) : 600 to 1600°C

d) The design of thermocouple assemblies shall be such that replacement on line is possible.

e) RTD (Resistance Temperature Detector) shall be platinum element 3 wire type with 100 ohms resistance at 0°C calibrated as per IEC 60651//DIN 43760. RTD shall be used within a temperature range of -200 to 650°C. Three-wire system shall be adopted in connecting the element.

f) RTD shall be used where accuracies of the order of 0.25% or better and smaller measuring spans are required.

g) Twin element sensors, if used, shall have two separate cable entries.

4.6.4 Temperature Transmitter

a) Temperature transmitters shall have a built-in line arising function to produce an output linear to temperature range.

b) Temperature transmitters shall have an accuracy of 0.075% of URV as a minimum. The accuracy shall be 0.25% for a calibrates range upto 0-100°C only.

4.6.5 Burn out protection must be provided with temperature transmitters and trip amplifiers. Upscale or downscale protection shall be decided based on its application to ensure fail-safe operation.
4.7 Pressure Instruments

Pressure instruments fall into three groups, direct reading instruments, transmitters and pressure switches.

4.7.1 Pressure Gauges

a) Pressure gauge dial shall be white, non-rusting plastic with black figures. The dial face shall be marked with pressure element material. Pointers shall have micrometer adjustment.

b) Pressure gauges shall be weatherproof with dial size of 150 mm and shall have features like screwed bezels, externally adjustable zero, over range protection (at least 130% of max. operating pressure) and blowout discs. Shatter proof glass Pressure gauge sensing element shall be of SS 316 and movement of SS 304, as a minimum.

c) Pressure gauges shall have an accuracy of "1% of URV as a minimum. Differential pressures gauges may have an accuracy of "2% of URV.

d) Over range protector and pulsation dampener, whenever used, shall be of SS 304, as a minimum. Pulsation dampener shall be used for all pulsating services. It shall be floating pin type, externally mounted and externally adjustable.

e) Pressure gauges with range as 0-60 kg/cm²g shall have safety type solid front case.

f) Connection shall normally be 1/2" NPTM bottom.

g) Cases shall normally be minimum SS-304 and weatherproof to IP -55 as per IEC-529/IS-2147. Blowout discs shall be provided.

h) Ranges shall be so specified that the gauge normally operates in the middle third of the scale and shall conform to IS -3624 standard dials, wherever possible.

i) Diaphragm seals, filled type or mechanical type shall be furnished where plugging of the element may occur or where suitable material is not available in highly corrosive services. When chemical seals are required, they shall be of the clean out type with flushing connection.

j) Where vibrations and pressure fluctuations are expected, glycerin filled type shall be used. Incase of vibrating service like pump outlets, flexible armored hoses shall be used in place of impulse piping and gauges shall be mounted separate stanchion.

k) Receiver pressure gauges for local transmitter output indication shall have 100 mm dial with stainless steel element and 1/4" NPTM connection.

l) The pressure element shall be Bandon, diaphragm or bellows depending upon process condition.

4.7.2 Pressure/Differential Pressure Transmitters

a) Pressure/differential pressure transmitter shall have electronic state-of-art capacitance or any other type of sensor meeting all functional specifications. Element material for transmitters shall be SS316, as a minimum, and shall be able to withstand over pressure of at least 30% of range or maximum working pressure which ever is higher.
b) All transmitters shall have an integral output meter. Remote mounted meters may be provided if required in addition.

c) Daphragm seal element with capillary shall be used for congealing, corrosive and highly viscous services.

d) D/P cells with one side open to atm osphere shall be us ed for low pressure at near atmosphere pressure.

4.7.3 Pressure Switches

a) Pressure switches shall have either diaphragm or bellow type of process element with SS 316 material of construction as a minimum. Switch type shall be sealed micro-type with contact rating suitable for specific application.

b) Pressure switches shall be blind type with 1/2 NPTF process connection and shall be operative in full-specified range. The switch differential shall be selected as per operating conditions.

c) Pressure switches shall have repeatability of "0.5% of URV, as a minimum pressure switch shall have over range protection of at least 130% of max. working pressure. The set pressure shall fall in the middle third (between 35% to 65%) of the adjustable range in general. Set point shall be field adjustable.

d) Receiver pressure switches shall have SS316 bellows as measuring element with 1/4" NPTF connection.

e) Pressure switch shall be provided with noble metal plated DPDT contacts and all have internally adjustable set point.

4.8 Level Instruments

4.8.1 Level gauges

a) All gauge glasses shall be steel armoured reflex or transparent type with body and cover material of forged carbon steel as a minimum and shall have tempered borosilicate glass with asbestos or other suitable gasket. Transparent type of gauges shall be provided with integral illuminators operating at 230 V 50 Hz supply and suitable for electrical area classification specified. All gauge glasses must have a rating equal to or more than the vessel design pressure and temperature.

b) Reflex type will be used for clean and colourless liquids, except liquids level interface. For low temperature, low boiling point service, large chamber type will be used. Transparent type will be used on acid, caustic, dirty or viscous, coloured liquids and liquid interface. Transparent type with Mica or Kel-F shields shall be used for treated water, boiler and condensate services, and for corrosive liquids, which will attack glass. Tubular gauge glasses shall, in general, not be used.

They may be used for non-hazardous services at ambient temperature and low pressures.

c) Large chamber gauges with frost shields shall be provided for cold services below 0°C. Heating jacket shall be provided for viscous liquids.
d) All gauges shall have top and bottom chamber connections, unless otherwise specified. In addition each gauge shall be provided with ball check valves and pipe union.

e) The visible range of level gauge shall be selected to cover the complete operating level as well as measuring range of the other level instruments provided for the same purpose. In general, the visible length of the level gauges shall be selected from the following:

<table>
<thead>
<tr>
<th>Visible length</th>
<th>Centre to Centre Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>220</td>
<td>470</td>
</tr>
<tr>
<td>470</td>
<td>720</td>
</tr>
<tr>
<td>720</td>
<td>970</td>
</tr>
<tr>
<td>980</td>
<td>1230</td>
</tr>
</tbody>
</table>

In any case, the maximum visibility length shall not exceed 1500 mm for a single gauge.

f) For level gauging in very viscous liquids and liquids with crystals, float operated magnetic gauges with 2" (50 mm) flanged end connections, shall be used.

4.8.2 Level Transmitter

a) Guided Wave Radar type instruments with side-side connections shall normally be used for level measurement upto 1219 mm. Ext display level instrument with side side connection. For interface Internal displacer type of level transmitters shall be avoided unless application necessitates its use.

b) All displacer type of level transmitters shall be of torque tube type with torque tube material of inconel, as a minimum.

c) Guided wave radar inst shall be + 3mm accuracy.

d) In general, guided wave Radar and displacer type instruments shall be used with displacer lengths of 356 mm, 813 mm and 1219 mm. For interface level measurement, displacer type instruments shall only be used.

e) Differential pressure transmitter shall be used for level measurement above 1219 mm, for services requiring purge or where liquid might boil in external portion.

f) Differential Pressure transmitters for use on corrosive or fouling service shall generally be diaphragm wafer with extended filled capillary type. Flush or extended diaphragm type differential pressure transmitter shall be considered for special applications only. Diaphragm material shall normally be stainless steel or any other special alloy.

4.8.3 Level Switch

a) Level switches shall generally be external ball float type with flanged head. Internal float/displacer type level switches shall only be used if ball float type is not possible, like in viscous services and in underground tanks.
b) Switch shall be sealed micro type with contact rating suitable for the specific application.

c) Level switch shall be furnished with SPDT contacts with adjustable differential, unless otherwise specified.

4.8.4 Tank Level Instruments

a) Each tank shall be provided with minimum 2 type of Tank level indication operating different principles one servo and other radar (Antenna) type..

b) Radar type transmitter shall be provided with + 5 mm accuracy for storage tanks and 1mm for custody transfer. Radar gauge shall be with 8” still well and 8” process connection.

c) Servo type instruments shall have 6” process connection with 12” dia still well, Servo accuracy + 5 mm is for storage tanks and 1mm for custody transfer.

d) The wetted material like float, displacer, tape, wire etc. shall generally be 316 SS.

d) The accessories for servo-controlled level gauge shall include calibration chamber and isolation ball valves for pressurized tanks.

e) Signal transmission shall be digital.

f) For Servo and Radar type instruments shall be capable of providing serial output as per vendor standard protocol or field bus protocol as per IEC-61158 in addition to analogue 4-20 mA DC current output. Also these instruments shall be capable of accepting input from multi element tank temperature sensors (thermocouple/ RTD) and transmit the same as a part of serial signal from the transmitter.

4.8.5 Other Special type of level instruments like ultrasonic, hydrostatic, nuleonic, capacitance, conductivity type shall be used as necessitated by application requirements.

4.8.6 For high pressure steam drum application conductivity type (Hydro a step or equivalent) level instrument along with GWR an DP type Level Transmitter shall be provided.

4.8.7 For solid level measurement, type of instrument shall be ul trasonic/radio frequency/ electromechanical/capacitance/nuleonic. The actual type selection shall be carried out based on the provenness of the selected type for the similar type of application.

4.9 Flow Instruments

The selection of flow measurement instruments shall be based on the requirement of accuracy, repeatability, location, physical properties of the flowing fluids handled, pressure drop, ease of maintenance and instrument cost.

In-line flow instruments shall have a direction of flow indication clearly marked and easily visible in the final installed position.

Flow switches shall not be used without prior approval from the purchaser.

Integral orifice meters, when used, shall be installed with block and bypass valves.
4.9.1 Orifice Plates

a) Flow measurement shall normally be carried out using thin square edged concentric orifice plate mounted between a pair of weld neck flanges of minimum 300 pounds ANSI rating for line size 2" and above. Flange taps shall be used for line sizes upto 12" while D-D/2 taps shall be used for line sizes 14" and above. The material of the orifice plates shall be normally SS 316, as a minimum.

Quadrant edge or quarter circle orifice plates shall be used for highly viscous liquids and for pipe Reynolds number below 10,000.

Conical entrance type of orifice plates shall preferably be used for very highly viscous liquids up to throat Reynolds number of 250. These plates shall be fabricated as per Flow Measurement Hand Book by R.W. Miller.

Vent and Drain holes shall be provided wherever necessary.

b) Sizing of orifice plate shall be carried out in accordance with ISO-5167 (Latest Edition). For orifice plates that are out of ISO 5167, sizing methods shall be ASME MFC-14M (latest Edition) or AGA Report No. 3 or ‘Flow measurement-Engineering Handbook’ by R.W. Miller.

c) Orifice plates shall be fabricated in accordance with standard STD-7-52-41 'Orifice Plates and Flanges Dimensional Details'.

d) Honed metering runs or integral orifice type transmitter shall be used in lines with 12" (40 mm) nominal diameter or below.

e) Upstream and downstream straight length shall be provided based on maximum d/D ratio of 0.75, in general. Where it is difficult to meet this requirement, the actual d/D ratio can be considered for reducing the straight length as permitted by the codes. The recommended practice shall be as per API-MPMS, Recommended Practices and AGA Report No.3. Flow straighteners should be considered, where straight runs are difficult to achieve, otherwise.

f) Meter taps shall be horizontal for liquids, condensible vapours and steam. The taps shall be on top for gas, non-condensible vapour, or liquids which boil at or below the maximum design ambient temperature at operating pressure. Where piping clearances are a factor, taps may be located up to 45E below the horizontal center line for condensible vapour, liquid and steam. The taps may be located up to 60E from vertical for gas and non-condensible vapour.

4.9.2 Venturi

Venturi shall as per ISO 5167 (Latest Edition) or ASME MFC-3M. Ventury throat shall be SS 304 minimum with divergent and convergent section as per Piping Material specification attached elsewhere in MR document. 100% radiography shall be considered where dissimilar welding.

4.9.3 Averaging Pitot Tube

Averaging pitot tube shall be considered for low pressure loss, high velocity steam, large diameter lines and air ducts.
a) The flow sensor shall be continuous averaging velocity head producing type of pitot tube with four or more equal averaging pitot tube sensing ports or continuous slots to suit line velocity profile. The sensor shall also incorporate a rear port for the measurement of line static pressure.

b) Averaging Pitot tube shall be of 3” flanged construction with isolation ball valve.

c) The insert retract mechanism shall be provide to allow on line removal and insertion of the average pitot tube under full pressure condition within the line.

d) Vibration analysis for each averaging pitot tube element shall be done for the indicated flow condition to ensure that the averaging pitot tube is of sufficient thickness and strength to withstand the vibration effects created due to Karman vortex shedding in the fluid stream.

e) The free end of the averaging pitot tube shall be pressure supported at the pipe wall. However, for the large pipe sizes and where vibration analysis recommends the requirement of end support, the end support/weld cap support shall be provided.

f) The offered averaging pitot tubes shall meet the following performance requirements

(i) Accuracy inclusive of repeatability and hysteresis shall be + 1% of actual value

(ii) Repeatability of averaging pitot tube shall be + 0.1% of actual value.

4.9.4 Variable area flow meters:

Variable area flow meters or rotameters shall be as per ISA-RP 16.1, 16.2, 16.3, 16.4, 16.5 and 16.6 and shall be used for viscous or corrosive services or where range ability in flow precludes the use of an orifice. Metal tube rotameters shall be used for all process fluids.

External devices for indicating or transmitting shall be magnetically coupled to the float or extension.

Glass tube rotameters shall be used for low pressure utility services for local indication and where line size is 1-1/2" (40mm) or less. Glass tube rotameters shall not be used if outlet line is connected to a line or vessel containing hazardous or toxic fluid unless a check valve is installed at the downstream side of rotameter.

4.9.5 Turbine Meters

Turbine meters shall be used for accurate flow integration for blending application, custody transfer etc.

Meter selection based on meter sizing shall be carried out in such a way that the maximum flow and normal flow shall not exceed the 90% and 70% respectively of the published normal metering range of the turbine flowmeter. Extended range shall not be referred for the meter selection.

When specified, the meter electronics shall be protected against transients induced by lighting and power supply surges. Transient protection electronics shall preferably be provided in the terminal block. The transient protection shall meet the requirements specified in IEC-60587.
a) Turbine flow meter shall be inline-mounting design type with flow direction clearly marked on the flow meter body to ensure correct installation. Insertion type turbine flow meter shall not be offered.

b) Flow meter design shall ensure that the location and/or orientation of installation i.e. mounting in horizontal and vertical line of turbine flow meter shall not affect the calibration, accuracy and performance of turbine flow meter of the meter.

c) The flow meter shall have an over range protection of at least 130% of specified range. Suitable protection shall be provide against over speeding.

d) The meter design shall also ensure protection against damage due

4.9.6 Target meters shall be considered for highly viscous hydrocarbon streams such as asphalt, tar, polymers etc.

4.9.7 Vortex meter shall be considered where high rangeability is the prime requirement.

4.9.8 Ultrasonic flow measurement shall be considered where non-intrusive flow measuring is required.

4.9.9 Differential Pressure type flow transmitter shall meet all the requirements specified in para.

4.10 Control Valves

4.10.1 Control valves shall normally be globe type, single seated or double seated. Other valve types like butterfly, ball, rotary plug, angle or 3 way etc., shall be selected as per service requirements.

4.10.2 Control valve sizing shall be carried out as per ISA S75-01. The valve shall permit upto 150% of normal flow or 110% of maximum flow, whichever is higher. In general, control valves shall be sized so that the valve opening is as noted below:

At max. flow : about 90% open
At normal flow : about 75% open
At minimum flow : about 20% open.

4.10.3 Flanged control valves shall be used. Body material, body rating and flange rating, shall be as per piping specifications as a minimum.

4.10.4 Minimum control valve body size shall be 1" in general. Reduced trims can also be considered. Body size shall be limited to 1", 1-1/2", 2", 3", 4", 6", 8", 10", and 12". Higher sizes may be used wherever necessary.

4.10.5 Material used for trim shall be SS 316, as a minimum. For higher pressure drops (greater than 10kg/cm²g), flashing, cavitation, erosive and slurry services and, in general, all steam services, trim shall be stellite. (wetted parts like seat ring, valve plug, plug guide, plug stem, guide busing and cage are being termed as trim).

4.10.6 Trim characteristics shall be equal percentage type unless required otherwise. Control valve plugs shall be top and bottom guided for double-seated valves and heavy top guided for single seated valves.

4.10.7 Anti-cavitation trim shall be selected wherever cavitation is expected in the valve.
4.10.8 Noise from control valve during operation shall be limited to OSHA specified level or better. The maximum allowable noise is 90 dBA SPL (Sound Pressure Level). Source treatment for noise shall be preferred by using special trims like anti-noise trims, in case noise exceeds the specified level. Other methods based on merit is permissible.

4.10.9 Valve seat leakage shall be as per ANSI/FCI 70.2 and shall be selected with due consideration to meet the requirement.

4.10.10 Flanged bolted type gland packing boxes shall be used. Packing shall normally be PTFE on liquid and gas service up to 200°C. PTFE impregnated asbestos shall be used above 200°C and up to 260°C with lubricator preferably. Graphite impregnated asbestos or equal, with lubricator, shall be used on steam service and temperature above 260°C.

4.10.11 Bellows seal shall be used where it is required to isolate the packing from the process fluid or where no leakage to atmosphere can be tolerated like toxic, explosive and precious fluids.

4.10.12 Material used for trim shall be minimum 316 SS, with guide bushing of hardened stainless steel like 440 C, 17-4 PH, all upto a pressure drop of 10 kg/cm². For higher pressure drops or erosive and slurry services and in general for all steam services, flashing services, hard surfacing of plug seat rings and seating area of inner valve with stellite shall be used. Special cases may require 17-4 PH seat ring and 440 C solid plugs or other materials like Hastelloy, Durimet, Monel etc.

For temperature above 300°C satellite facing shall be used for guide posts. Guide bushing shall always be harder by a minimum of 125 Brinell than the guide post.

4.10.13 In general, block and by pass valves shall be installed with all control valves upto and including 2" size except for butterfly valves, 3 way valves and slurry and freezing service. Hand wheel shall be provided for all other sizes and services. No by-pass valve or hand wheel shall be used for shutdown valves.

4.10.14 Valve actuator shall be pneumatic spring opposed diaphragm type, in general. Piston type actuators may be used for very high shut off pressure requirements. Additional equipment necessary to meet fail safe condition shall also be included in case double acting piston type actuator is selected. In either case, actuator shall be able to withstand maximum shut-off pressure with the minimum instrument air pressure specified.

4.10.15 Valve positioners wherever used shall be side mounted force balance pneumatic type or electronic instrumentation, I/P converter shall be used along with pneumatic positioners. Separate air filter regulator shall be used for each valve positioner.

4.10.16 Smart type and field bus type positioners

Digital smart positioners or field bus type of positioners with diagnostic capabilities shall be provided whenever specified in the purchaser’s data sheets. These shall meet the following minimum requirements:

a) The positioner sensor and sensing mechanism shall be rugged and shall not be effected by the line/valve vibration. The performance of the positions shall be immune to above vibration.

b) The positioner’s output and input range shall be field adjustable without any hardware modification. The output from the positioners shall be available for both single acting as well as double acting actuator.
c) Each positioner shall be operable, configurable and accessible through HART compatible hand held configurator/field bus configurator as applicable. Smart positioners shall also have a dedicated operating panel for the above functions.

d) Contractor shall provide the valve’s operating signatures in the form of hard copy and soft copy for each control valve provided with smart positioners. The necessary software for advanced control valve diagnostics like seat ring condition, gland packing condition, actuator leakage etc. shall also be included.

e) Fieldbus positioner shall have the capability to perform functions like PID etc.

f) All positioners shall have metallic casing and cover either of stainless steel or of anodized Aluminium.

4.10.17 Whenever limit switches are specified as inductive proximity type, these shall meet NAMUR (DIN-19234) requirements.

4.10.18 Solenoid valves, wherever used, shall be universal type and shall be continuous rated type with class F coil insulation as per IEC 85/IS 1271. These shall be of brass body with SS316 trim, as a minimum.

4.10.19 Self-actuating regulators for flow, pressure and temperature shall be used where loads are constant and requirements of precision and accurate controls are not stringent.

4.11 Pressure Relief Valves And Rupture Discs:

4.11.1 Pressure Relief Valves

4.11.1.1 All pressure relieving devices shall be designed in accordance with ASME code for 'Boilers and Pressure Vessels', API-521 and Indian Boiler Regulations.

4.11.1.2 Pressure relief valves shall be full nozzle full lift type except for thermal relief valves.

4.11.1.3 Conventional valves shall be specified for constant back pressure while bellows seal type valves shall be specified for variable back pressure more than 10% of set pressure. Pilot operated pressure relief valves shall be used for special services and where set pressure is closer than 10% of the operating pressure, in general.

4.11.1.4 Lifting lever shall be specified for steam and air service. Open bonnet shall be used for steam service.

4.11.1.5 The percentage accumulation in case of pressure relief valves/safety valves shall be as follows:

   a) Steam Service
       - ASME SEC I 3%
       - IBR (Before steam let-down station) 5%

       - IBR (Distribution & utilities) and 10%
ASME Section VIII

b) Gas, Vapour or liquid except in para 10%
   4.12.1.5(c) & (d)
   c) Liquid for thermal Relief 25%
   d) Fire exposure on unfired vessels 21%

4.11.1.6 3/4" x 1" threaded (NPT) modified nozzle type valves with typically 0.38 cm² orifice size shall be specified for thermal relief.

4.11.1.7 The body material shall, as a minimum, be as per piping specifications. Nozzle and disc material shall be SS316 as a minimum with machined stainless steel guide and spindle. Whenever semi nozzle designs are unavoidable, body material shall be at least same as nozzle material.

4.11.1.8 The spring material of pressure relief valves shall be as follows unless otherwise necessary because of process conditions:

<table>
<thead>
<tr>
<th>Temperature Range</th>
<th>Spring Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>29°C to 250°C</td>
<td>Cadmium/nickel plated carbon steel.</td>
</tr>
<tr>
<td>above 250°C</td>
<td>Tungsten alloy steel.</td>
</tr>
<tr>
<td>below – 29°C</td>
<td>Stainless steel 316</td>
</tr>
</tbody>
</table>

4.11.1.9 Flanged connection shall be for standard sizes 1" or larger. Minimum flange rating shall be 150 pounds ANSI.

4.11.1.10 Where permissible, screwed connections shall be used on sizes 3/4" and below.

4.11.2 Rupture Disc

4.11.2.1 Rupture discs shall be reverse buckling type, in general and shall be supplied in pre-torqued holder assembly, which shall fit inside the inner diameter of the bolt circle of standard flanges. Disc material shall be compatible with the vessel contents and shall be consistent with the bursting requirements. Inconel discs shall be used above 100°C if compatible with the process fluid.

4.11.2.2 When rupture disc is used upstream of a pressure relief valve, a pressure gauge shall be provided on the downstream of the disc to indicate any rupture of the disc in addition to an excess flow check valve. In addition combination capacity factor of 0.9 shall be used for sizing unless the combination has been tested and approved for any other combination capacity factor.

4.11.2.3 The bursting tolerance of the rupture disc shall be *5% of the specified bursting pressure or less, unless otherwise specified.

4.12 Interlock And Shutdown System

4.12.1 Interlock and Shutdown System shall be an independent system with its own dedicated primary element except for orifice flow measurement. For orifice flow element separate flow
transmitter for shut down / interlock shall be considered. In no case the initiating signal / contacts shall be derived from indicators, controllers, recorders, scanners, alarm annunciator or any such instrument.

4.12.2 The system shall be designed fail safe and shall meet the following requirements, as a minimum:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>All initiating contacts shall be close under normal conditions and shall open under abnormal conditions.</td>
</tr>
<tr>
<td>b)</td>
<td>All relays and solenoid valves shall be energised under normal conditions and shall de-energize under abnormal conditions.</td>
</tr>
<tr>
<td>c)</td>
<td>Emergency shut down switch contacts shall be wired in series with the final actuating device to ensure positive shutdown.</td>
</tr>
<tr>
<td>d)</td>
<td>If desired, because of operational or maintenance requirements, adequate trip by-pass facilities are to be provided with warning lights to indicate that the trip has been bypassed. Trip bypass alarms shall be provided in local as well as in remote location. All such by-pass switches shall be key-operated type.</td>
</tr>
</tbody>
</table>

4.12.3 The system when designed using electromagnetic relays as per job specification shall be located locally or remotely as per the operational requirements. The system shall meet the following requirements as a minimum:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>The electromagnetic relays shall be low power continuously rated type and shall have LED for status indication.</td>
</tr>
<tr>
<td>b)</td>
<td>The relays shall be plug-in-type and their plug-in-bases shall have screwed terminals for interconnection. Lug type soldered connection shall not be acceptable.</td>
</tr>
<tr>
<td>c)</td>
<td>Each relay shall have three numbers of ‘NO’ and three number of ‘NC’ contacts, as a minimum each suitable to drive the connected load. Out of these, one ‘NO’ and one ‘NC’ contacts shall not be used.</td>
</tr>
<tr>
<td>d)</td>
<td>Each shutdown/interlock logic shall be individually protected using separate switch fuse unit and shall have a lamp for indicating power healthy status.</td>
</tr>
</tbody>
</table>

4.12.4 Each shutdown circuit and solenoid valve shall be provided with a switch-fuse unit separately.

4.12.5 The system shall be designed using Programmable Logic Controller (PLC) located in environmentally controlled remote control room. Unless specified otherwise. This shall meet the following minimum requirements:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>PLC shall have dual redundant processor configuration as a minimum. Additional redundancy for I/O's/Power Supply/Communication network shall be provided whenever specified.</td>
</tr>
<tr>
<td>b)</td>
<td>The software shall include the operating system and application program. The application program shall include software for performing functions like interlock and shutdown logic, programming/program modification, documentation etc. Two copies of application program and two set of licensed system software shall be supplied.</td>
</tr>
<tr>
<td>c)</td>
<td>The system shall be supplied with programming tools and related accessories.</td>
</tr>
</tbody>
</table>
d) No two shut down circuits shall be shared by same I/O module, unless specified otherwise.

e) PLC specifications shall be as per clause 6.0 of this specification.

4.13 Compressor Instrumentation

4.13.1 Compressor vendor shall be completely responsible for providing adequate instrumentation for safe and efficient operation of the machine. The commonly used instruments are being detailed out in the following clauses, however this does not absolve the vendor of providing additional instrumentation, if required.

4.13.2 Anti surge and performance control system (ASC).

   a) Vendor shall be fully responsible for the complete design of Anti surge/performance control system (ASC) including selection of type of flow element, controller Algorithm, type of explosion protection, type and operating timings of final control element. Vendor shall guarantee the performance of machine with the offered ASC system. Wherever required, ASC system shall be designed in such a way that it is capable of correcting the compressor operating point so as to avoid surge in order to protect machine from possible damage, to minimize process upsets and to minimize recirculation.

   b) ASC system shall typically consist of but not limited to flow element, flow transmitter, differential pressure transmitter, ASC controller, control valve and other accessories as felt necessary by the Vendor.

   c) Vendor shall supply all the hardware and software related to the operation and safety of the compressor. This shall include but not limited to the following:
      ▪ Design and operation of surge control loop scheme based on offered compressor, performance.
      ▪ Supply of all hardwares in antisurge control loop including dedicated controller, transmitters, measuring elements, final control element etc.
      ▪ Fast response transmitter and control valve etc. as required.
      ▪ Algorithm required for antisurge/Performance control application.

   d) The ASC shall be a dedicated single loop controller on proprietary Hardware Platform or single/multi loop controllers of common hardware platform such as PLC. The single loop controller shall be dedicated controller for each Anti-surge or Performance control application/Tag. Dedicated panel mounted facia shall be provided. The ASC system when provided on common hardware platform shall be with redundant configuration as minimum viz-dual processor, dual input/output, redundant communication & dual power supply system. The multiloop controller/system shall be dedicated for Antisurge/Performance applications/Tags of each machine/each machine tag. Unless specified otherwise dedicated panel facia for each application shall be provided to mount on hardwired console in control room.

   e) It should be able to accept 4-20 mA signal from field or from HIC at purchaser DCS or at LCP as a manual override to anti-surge control system with bump less transfer.

   f) Auto-manual operation with bump less transfer shall be provided.

   g) The controller response time (total time to read input, processing time and output) shall be as per the machine dynamics and safety and shall be of the order of max. 40-milisec. Any faster response required based on machine dynamics shall be considered.
by vendor. The input sampling interval shall be as per machine dynamics within the controller response time as above. The processor cycle time shall be considered to meet the overall response time.

h) The ASC shall be field proven, specific to the make of machine and for the similar application in hydrocarbon industries. Bidder shall provide the proven track record for the offered ASC meeting the above.

i) The Anti surge/Performance control algorithm shall be implemented using standard firmware in the controller/Processor system.

j) The Algorithm developed by vendor shall be specific for given application, surge control, performance, load sharing etc. and shall be field proven for the compressor make.

k) The algorithm implemented in the system shall be protected against any modifications/changes.

l) The configuration shall be stored in non-volatile memory or battery back-up for configuration shall be provided (min 72 hours) in case of volatile memory along with battery drain indication.

m) In case of ASC on common hardwired platform separate configurator with necessary hard ware/ soft ware shall be provided for application programming.

n) Anti surge controller shall not be used for performing any other machine related inter locks/logics.

o) All the instruments (transmitters, I/P converters and temperature elements and / or transmitters) connected with anti-surge control loop shall be flame proof "EEExd" type suitable for the area as specified. The suitability of smart transmitter shall be confirmed by vendor and to be provided accordingly.

4.13.3 Machine Monitoring System (MMS):

Machine Monitoring system shall be provided for continuous monitoring and indicator of machine parameters like vibration & axial displacement, bearing and winding temperature, keyphasor etc.

4.13.3.1 Vibration and Axial Displacement Monitoring

4.13.3.1.1 The machine monitoring system shall be Bently Nevada 3500 or equivalent, the system shall be provided with built in intrinsically safe barrier and shall be duly mounted in separate panel. No external barrier shall be provided for the same.

4.13.3.1.2 For MMS the display unit shall be provided at local control panel with necessary statutory certification. Alternately purged enclosure is also acceptable with necessary certification.

4.13.3.1.3 Vibration and displacement monitoring system shall be as per API-670. The extent and type of monitoring shall be as defined elsewhere. However, vendor shall furnish any additional requirements for monitoring deemed essential by them with reasons. Two probes at 90 degree apart for each location shall be provided and connected to same dual channel monitor for vibration monitoring.
4.13.3.1.4 The sensing probe shall be accessible for adjustment, repair and replacement without dismantling the machine.

4.13.3.1.5 Vendor shall provide continuous 4-20 mA dc isolated output for each channel of measurement for remote indication and potential free contacts for alarm/shutdown setting from the monitors.

4.13.3.1.6 In addition to this, it shall be provided with necessary hardware (communication Gateway Module) (including the cable for serial data communication from monitoring system to purchaser’s DCS) for machine monitoring through purchaser’s DCS via redundant serial data interface between this system and purchaser’s DCS. Bidder shall furnish all details like pin configuration and tag number wise MODBUS address mapping list etc. for smooth interfacing of this communication link with DCS.

4.13.3.1.7 Bidder shall also supply one common laptop based configuration unit for the package unit with required configuration software and hardware for configuration of MMS system including the serial communication cable required between configuration unit (laptop) & MMS monitors.

4.13.3.1.8 Monitors shall be dual channel type and shall meet the following specifications as a minimum:

   a) Continuous two channel monitoring with each channel input from one probe. Readout scale shall read higher of the two sensors.

   b) Each channel shall have two independent alarm levels one for pre trip alarm and one for each trip, settable continuously over measurement range. Two relay contacts for each pre trip alarm and trip alarm per channel shall be provided.

   c) Broken sensor failure detection without causing shut down.

   d) LED lamps on monitor front for each channel to indicate pre-trip alarm, trip-alarm and circuit not OK conditions.

   e) Selector switches on monitor front to read vibration/ displacement pre-trip alarm and trip set points for each channel shall be provided.

   f) Analog output 4-20 mA dc isolated signals shall be provided for each channel for remote indication.

4.13.3.2 Bearing & Winding Temperature Monitoring

4.13.3.2.1 In general, bearing temperature shall be measured at the points which are under maximum loading.

4.13.3.2.2 Sensor shall be three wires RTD element of platinum having 100 ohms resistance at 0°C. Calibration shall be to DIN 43760 standards.

4.13.3.2.3 The temperature sensor, cables, terminal heads, junction boxes etc. should be capable of withstanding the mechanical vibration and environment of a rotating machinery atmosphere.

4.13.3.2.4 Bearing and Winding temperature shall be monitored by means of a temperature monitor. The temperature monitors shall be mounted on the local control panel in hazardous area and shall meet following requirements:
a) Accept RTD inputs (platinum, 100ohm at 0°C calibrated to DIN 43760 standards).

b) Continuous six channel monitoring with each channel input from one RTD. Read out scale shall read higher of the six temperatures.

c) Each channel shall have two independent alarm levels one for pre-trip alarm and one for trip alarm, settable continuously over measurement range.

d) Broken sensor failure detection without causing shut down.

e) Selector switches on monitor front, to read temperature, pre-trip alarm and trip set points for each channel shall be provided.

f) Analog output 4 - 20 mA dc isolated signals shall be provided for each channel for remote indication.

g) Monitor shall be Bentley Nevada 3500 series or better.

4.13.3.2.5 Separate temperature monitors shall be provided for motor winding and bearings temperature monitoring.

4.13.3.3 Key Phasor

4.13.3.3.1 Key phasor system shall be provided by vendor for performing analysis of vibration signals to determine machine malfunctions. It shall consist of a proximity probe and transmitter, extension cable etc. and other accessories to make the system complete. Vendor shall provide necessary reference on the shaft to determine one-per-turn occurrence.

4.13.4 Speed Governor System

Digital microprocessor based fault tolerant triple modular redundant governing system of mounted in standalone cabinet and located in rack room.

4.13.4.1 HMI for operator interface shall be supplied loose with all mounting accessories for mounting this HMI in purchaser’s hardwired console in general. This shall include all basic features of governor to enable operator to do all control and monitoring operations from console itself. 4.13.4.2 This shall include features like assignable speed range, adjustable speed set point, remote speed set point input, digital speed indication, adjustable speed ramp, override for testing the external over speed trip system etc.

4.13.4.3 It should be able to accept 4-20 mA signal from HIC at purchaser’s DCS or LCP as a manual override to governor and pass on the same, after a bump less auto / manual selection & local / remote selector switches configured in woodward governor (shall be possible through HMI) to governor valve as manual control.

4.13.4.4 Bidder shall provide all hardware & software in the system (including the cable for serial data communication from system to purchaser’s DCS ) for serial communication link for all data transfer from governor to purchaser’s DCS. This serial link shall be RS 422 / RS 485 with MODBUS RTU protocol, bidder shall furnish all details like pin configuration and tag number wise MODBUS address mapping list etc. For smooth interfacing of this communication link with DCS.

4.13.4.5 The Governor Control System shall be Woodward or equivalent.
4.13.5 Accumulator of Lube Oil System

4.13.5.1 If accumulators are used with nitrogen for lube oil dampening at the desired pressure to meet the system requirement the following instrumentation with the accumulator to be provided by vendor:

a) Accumulator shall have charge kit with isolation valves and connection hoses.

b) Standard Nitrogen cylinders available in India are at pressure of 140 k g/cm² with standard connection sizes. Vendor shall provide the complete regulator system with protection for charging Nitrogen from Nitrogen cylinder to accumulator at the desired pressure. Regulator shall be suitable for the inlet pressure variation of 140 to 150 kg/cm² while charging with suitable inlet connection to match the Nitrogen cylinder connection. Regulator system shall have pressure indicator, regulator, relief valve, needle valve etc. as a minimum. Material of construction shall be stainless steel.

4.13.6 The compressor loading-unloading scheme for reciprocating compressors shall be provided as per the minimum requirements specified in the job specifications. Manual as well as automatic schemes shall be provided.

4.13.7 Emergency switch shall be provided in the local panel/local. All such switches shall have a protective cover to avoid inadvertent shutdown.

4.13.8 Vendor shall provide the following common alarms for purchaser:

a) Common machine pre-trip alarms.

b) Common machine trip alarm.

4.14 System Cabinets, Racks And Consoles

4.14.1 All system cabinets, marshalling racks and hardwired consoles shall be free standing and enclosed cubicles type. All these items shall have bottom cable entry.

4.14.2 Cabinets shall be fabricated from cold rolled steel sheet (CRCA) of minimum 2.0mm thickness suitably reinforced to prevent warping and buckling. Doors shall be fabricated out of 1.6 mm thick CRCA sheet. Cabinets having modular construction and with basic frame structure of heavy duty aluminium shall also be acceptable.

4.14.3 Cabinet/Console finish shall include sand blasting, grinding, chemical cleaning, surface finishing by suitable filler and two coats of high-grade lacquer with sanding between coats. Two coats of paint in the cabinet colour and a final coat after assembly at site, shall be given for non-glossy high satin finish.

4.14.4 In order to remove dissipated heat effectively vent louvers backed by wire fly screen shall be provided. Further, ventilation fans shall be provided wherever required. High temperature annunciation shall be provided on operator console.

4.14.5 Illumination shall be provided for all cabinets by LED lamps, which shall be operated by door switch.

4.14.6 All cabinets/racks/consoles shall be adequately sized to avoid any congestion. Wiring shall be done as per guidelines provided in clause 4.3.14 of this specification.
4.14.7 The height and colour of the cabinets shall be inline with other equipments being installed in the control room.

5.0 DISTRIBUTED CONTROL SYSTEM

5.1 General

5.1.1 The system shall be a microprocessor based having functional distribution and data base distribution sub-system wise. The system shall be of modular construction and expandable in future by adding additional modules.

5.1.2 On-line replacement of any module shall be possible in such a way that removal and addition of a module shall be possible without de-energizing the system. Further, there should not be any interruption in the system while replacing a faulty module wherever redundant modules are provided.

5.1.3 Galvanic isolation shall be provided for all field signals.

5.1.4 All sub-systems of this system shall be able to operate satisfactorily from 15°C to 30°C and 20 to 80% of non-condensing humidity.

5.1.5 The system shall have the capability of detecting open sensors.

5.1.6 DCS should be provided with licence free of cost with eXpandability

5.2 Spares Philosophy

5.2.1 Vendor shall provide installed spares of 10% for each type of input/output modules to enhance the system functional requirements. The system shall also have the software capability to take care of these installed spares.

5.2.2 Vendor shall also provide the following spares in addition:

a) 5% mandatory spare or one of each type of module used in the system including all processor, memory communication and power supply modules but shall not include TFT printers, disc drives etc.

b) Consumables spares for a minimum of six months duration after system acceptance which shall includes paper, ink, cartridges etc for printers., assignable recorders, video copier etc.

c) Commissioning spares

d) 2 years of continuous operational spares (to be quoted separately).

5.3 Functional Specifications

5.3.1 Functional Requirements

The system, as a minimum, shall meet the following requirements without any supervisory computer:

a) Control, data acquisition and monitoring

b) Alarming
| c) | Historical data storage, archival and retrieval |
| d) | Logging and report generation |
| e) | System configuration and builder facility. |

### 5.3.2 Controller and Data Acquisition Sub-system

a) The control function shall be executed by microprocessor based multiloop controllers. Each multiloop controller along with its related I/O's shall be backed up by a similar redundant controller which shall take over on the failure of the main controller. The switch over time shall be of the order of 1 second.

b) Redundancy shall be provided for all data acquisition points also if a single module handles more than 16 analog I/Os or 32 digital I/Os at any stage.

c) Controller and data acquisition sub-system shall be able to scan close loops in less than 500 milliseconds and an open loop in 2 seconds.

d) It must be ensured that processor and memory loading shall not exceed 60% under the worst loaded conditions.

e) Controller and data acquisition sub-system shall be able to implement required control and data acquisition strategies like signal conditioning, linearisation, compensation, square root extraction, summation, subtraction, logic functions, high-low selection etc. as a minimum. Other algorithms shall also be possible to be executed if required for the package unit control.

### 5.3.3 Operator Interface Sub-System:

a) Operator interface sub-system shall provide the centralized information to the package unit operator/engineer in the following fields:

- Indication of all analog and digital process variables.
- Manipulation of control loops.
- Alarm displays and annunciation.
- Graphic displays.
- Logging and trending.
- Self diagnostic messages.
- System configuration and display building.

b) Operator interface sub-system shall consist of operator console each with three 19" colour TFTs, three set of keyboards, alarm and event printer and logging printer.

c) Each TFT keyboard of operator console shall either be driven by independent electronics or common redundant electronics.

d) All the functions of TFT's and keyboards of an operator console shall be fully interchangeable. Further any change made in the database of one TFT's shall automatically update the data base of other TFTs of the same console.
e) TFT data display update rate shall not be more than two seconds.

f) A minimum of 8 digits shall be required for tag number and 15 digits for process description.

g) Keyboard shall preferably be touch sensitive type, spill proof and shall have a key lock to restrict engineering functions. Functions like data base configuration, alarm settings, graphic compilation, real time clock setting, alarm inhibiting etc shall be restricted through key lock.

h) Process Displays:

System shall be able to display adequate number of hierarchical views like overview, group and loop display easily accessible through keyboard.

i) It shall also be possible to display and control process package through dynamic graphics. System shall have enough capacity to display complete package through dynamic graphics.

j) Real time trend and Historical trends shall be possible. Real time trend shall have sample time of 10 second and shall be available for minimum 1 hour. Historical trend shall be possible with a minimum sample time of 1 minute and shall be available for 25 hours.

k) Tuning trend shall also be possible with sample time of at least 1 second.

l) Facility shall be available in the system for archival of historical data either on tape or on floppies.

m) Alarms shall be displayed as and when they appear irrespective of type of display distinguished by flashing and colour change. Alarm summary and alarm history shall also be possible in the system.

n) System alarms shall also be annunciated as reported by self-diagnostic routines. Status of various sub-systems connected on the communication sub-system shall be provided on configuration display.

o) Various log reports shall be generated and printed on the logging printer. The log reports required shall be shiftly (8 hourly) report, daily report, daily production report, shutdown report, on-demand report etc. Various alarms process or system and events shall be printed on the alarm and event printers as and when they appear. Formats for log reports shall be user definable.

p) Data archival and retrieval facilities shall be available in the system.

q) Deleted

5.3.4 Communication Sub-system:

a) The communication sub-system shall be dual redundant serial communication bus for connecting various sub-systems. Each sub-system shall be connected to bus using redundant communication interfaces.

b) Suitable methods shall be used for error checking on all data transfer. The mechanism used shall be transparent to the user.

c) Any redundant Fibre optic cable coming from Field to DCS/PLC shall be through Separate route , separate cableduct/tray
6.0 PROGRAMMABLE LOGIC CONTROLLER

6.1 General

6.1.1 The programmable logic controller shall be micro processor based system. The system shall be in addition be of modular in construction and expandable in future by adding additional modules.

6.1.2 On-line replacement of any module shall be possible in such a way that the removal and addition of any module shall be possible without de-energizing the system. Further there shall not be any interruption in the system while replacing a faulty module except for the inputs/outputs, which are being handled by the module.

6.1.3 Programmable logic controller shall be able to operate satisfactorily from 15OC to 30OC and 20% to 80% non-condensing humidity. The system shall be installed in environmentally controlled control room unless specifically indicated otherwise.

6.1.4 The system shall have extensive set of self diagnostics hardware and software for easy and fast maintenance. Diagnostics shall be required at local as well as a console level.

6.1.5 Separate power supply unit shall be provided for individual I/O rack and processor unless otherwise specified. Suitable battery (Note 1) back-up shall be provided for volatile memory protection.

6.1.6 Operation of PLC shall be completely unaffected by a momentary power loss of the order of 20 milli seconds.

6.1.7 The system shall be programmed in general as per the logic diagram or ladder diagram.

6.1.8 No single mode failure shall affect the system whenever redundant system configuration is specified.

6.2 System Configuration

6.2.1 Vendor shall offer system configuration as per the respective job specifications. However, each sub-system offered shall meet the minimum requirements specified in the following paragraph.

6.2.2 Input/output Sub System

6.2.2.1 The maximum number of input/output per I/O module shall not exceed the following:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Type of Configuration</th>
<th>No. of I/Os</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Single I/O system</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Dual I/O</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>Triple Redundant System</td>
<td>32</td>
</tr>
</tbody>
</table>

6.2.2.2 Each I/O shall be electrically isolated from external control circuit by suitable means. The minimum isolation level between I/O and logic circuit shall be 1000 V dc.

6.2.2.3 Each I/O shall be protected against the reversal of polarity of the power supply voltage to I/O.

6.2.2.4 Each module shall have a LED for each I/O per channel to indicate the status of each Input/output.

6.2.2.5 The output control rating shall be as follows:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Application</th>
<th>Voltage Rating</th>
<th>Current Rating</th>
</tr>
</thead>
</table>

Note: 1 Spare Battery Shall be provided
1. All output cards for driving solenoid valves  110 V dc  0.5 A Inductive  
2. All output cards for alarm annunciators  24 V dc  2.0 A Inductive  
3. All LT motors/pumps/compressors output cards unless otherwise specified  240 V ac  5 A Inductive  
4. All HT motors/pumps/compressor (6.6 kV and above) unless otherwise specified.  220 V dc.  2.0 A Inductive

6.2.2.6 Each output shall be short circuit proof and protected by using fuse. Visual indication of fuse blown must be provided for each output.

6.2.3 Processor Sub-System

6.2.3.1 The processor shall have capability to implement all the control functions required to execute the logic schemes. The size of the memory shall be sufficient for the storage of the programme instructions required by the logic schemes.

6.2.3.2 Memory shall be non-volatile. In case volatile memory is provided, battery backup shall be provided for a minimum of three months to keep the storage intact. A battery drain indication shall be provided at least one week before the battery gets drained.

6.2.3.3 Whenever dual processor is specified, redundancy shall be provided such that in case of failure of main processor the standby processor shall take over automatically without any bumps. Redundancy shall be provided for complete processor sub-system including CPU, memory and power supply. In case of failure of complete processor system, output shall take fail-safe state automatically.

6.2.3.4 In case of triple redundant system, all the three processors shall execute the same instruction / programme and check their results and majority vote to correct any faulty result.

6.2.3.5 It shall be possible to generate the first out alarm output by the PLC.

6.2.4 PLC Console

6.2.4.1 The PLC console shall be used for programming, programme storage, fault diagnostics and alarm monitoring. It shall also be possible to use this for plant operation, whenever specified.

6.2.4.2 It shall consist of a single colour 19" size TFT screen, one programming keyboard and operating keyboard, whenever specified.

6.2.4.3 The keyboard shall preferably be touch sensitive sealed type, easy to operate with each key clearly identified. It shall be provided with a lock and key to prevent any unintentional programme modification.

6.2.4.4 It shall be possible to modify, add or delete the application programme online without affecting the output.

6.2.4.5 Whenever PLC TFT’s is used for plant operation, it shall be 19" colour TFT and shall be able to display process dynamic graphics, overview and group displays.
6.2.4.6 It shall be possible to printout the Ladder/logic diagram on the PLC printer. In addition printer shall also print the diagnostic messages and reports, shut down report, I/O map, process alarms etc.

6.2.4.7 PC based console when offered must be of current release and state-of-the art.

6.2.5 System Power Supplies

6.2.5.1 Programmable logic controller shall operate on uninterrupted power supply with following specifications:

- Voltage: 110V "10%
- Frequency: 50 Hz " 3 Hz
- Switchover time: 5 millisecond

6.2.5.2 Each I/O rack shall be provided with a separate power supply.

6.2.5.3 Each processor unit shall be provided with separate power supply.

6.3 Self Diagnostics

6.3.1 The system shall have extensive set of self-diagnostic sub-routines which shall be able to identify the system failure at least up to module level. At local level, failure of a module shall be identified by an individual LED.

6.3.2 Whenever auto-testing of I/O modules is specified, the testing software must be capable of detecting faults in case of normally open as well as normally close system.

7.0 LIST OF DOCUMENTS ATTACHED

- STD-7-52-001 Instrument Connections on Vessels & Tanks
- STD-7-52-002 Instrument Connections on Piping.
- STD-7-52-035 Thermowell
- STD-7-52-041 Orifice Plates and Flanges -Dimensional details.
- STD-7-52-254 Duct Fabrication Details

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ANNEXURE-I

VENDOR DATA REQUIREMENTS

(INSTRUMENTATION)
## VENDOR DATA REQUIREMENT

### (INSTRUMENTATION)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>Document Inf. Review</th>
<th>Category As built</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Drawing and Document Schedule</td>
<td>*</td>
<td>*</td>
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<tr>
<td>2.</td>
<td>Piping and Instrument Diagram</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>3.</td>
<td>Instrument Index</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>4.</td>
<td>Sub-Vendor List for Instruments and accessories</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>5.</td>
<td>Instrument Sizing calculations</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>6.</td>
<td>Utility requirements</td>
<td>*</td>
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</tr>
<tr>
<td>7.</td>
<td>Level Sketches</td>
<td>*</td>
<td>*</td>
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<tr>
<td>8.</td>
<td>Material requisition</td>
<td>*</td>
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<tr>
<td>9.</td>
<td>Purchase Requisition</td>
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<tr>
<td>10.</td>
<td>Functional schematic</td>
<td>*</td>
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<tr>
<td>11.</td>
<td>Logic diagrams</td>
<td>*</td>
<td>*</td>
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<tr>
<td>12.</td>
<td>Instrument loop drawings</td>
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<tr>
<td>13.</td>
<td>Control room layout</td>
<td>*</td>
<td>*</td>
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<tr>
<td>14.</td>
<td>Panel front arrangement</td>
<td>*</td>
<td>*</td>
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<tr>
<td>15.</td>
<td>Power Supply Distribution</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>16.</td>
<td>Wiring diagram for panels</td>
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<tr>
<td>17.</td>
<td>Configuration diagram</td>
<td>*</td>
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<tr>
<td>18.</td>
<td>I/O assignment</td>
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<td>19.</td>
<td>Instrument Duct/Tray layout</td>
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<tr>
<td>20.</td>
<td>Instrument Cable schedule</td>
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<tr>
<td>21.</td>
<td>Instrument location plans</td>
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<td>*</td>
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<tr>
<td>22.</td>
<td>Instrument installation drawings</td>
<td>*</td>
<td>*</td>
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<tr>
<td>23.</td>
<td>Bill of material for installation items</td>
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<tr>
<td>24.</td>
<td>Spare part list for</td>
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<tr>
<td></td>
<td>a) 2 years operation</td>
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<tr>
<td></td>
<td>b) Start up and commissioning</td>
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<td>c) Spare instruments (10%)</td>
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<td>Inspection and test procedure</td>
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<td>26.</td>
<td>Complete catalogues with part list for all vendor supplied instruments, control, etc.</td>
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<td>27.</td>
<td>Installation, operation and maintenance manuals</td>
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**Note:** This list indicates the minimum drawings and document requirements. However, the vendor shall submit a complete list of document and drawing schedule listing all drawings and documents to be submitted.

**FORM NO:** 02-0000-0021F2 REV1

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submitted by them during the course of execution of the job. The schedule shall list all drawings and documents along with their number and expected date of submission.

ANNEXURE - II

MATERIAL SELECTION CHART

(INSTRUMENTATION)
MATERIAL SELECTION CHART

1.0 All materials shall be as per PMS attached elsewhere.

2.0 For all instruments in sour service, all materials of construction shall meet the requirements specified in NACE MR01-75 latest edition. In addition, any other requirements if specified in respective piping class, shall also be complied.

3.0 For testing requirements like Radiography, IBR, NACE, Hydrogen testing, Post weld heat treatment, etc shall be followed as per piping material specification for the respective piping class.
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**PART II**

SPECIFICATION FOR MATERIAL, INSTALLATION, TESTING AND COMMISSIONING.
CONTENTS

1.0 INSTALLATION MATERIALS

2.0 INSTALLATION

3.0 TESTING AND CALIBRATION

4.0 COMMISSIONING
1.0 INSTALLATION MATERIALS

1.1 Vendor shall ensure and supply all erection hardware required for the installation of complete instrumentation which form a part of the package unit. This includes items like cables, cable glands, junction boxes, instrument valves and manifolds, mounting accessories, impulse piping/tubing, pipe/tube fittings, pneumatic signal tubes, air line pipes and fittings, filter regulators, steam/electrical tracing, insulation materials, cable duct and trays, conduits, identification tags, structural material required for instrument supports and trays etc.

1.2 Clause 1.1 above broadly covers the items required for any typical plant, however the vendor shall supply all necessary items to make the installation and commissioning work complete in all respects, irrespective of whether these have been explicitly included in their scope or not.

1.3 Salient features and minimum requirements for some of the main installation materials is being described in the following paragraphs. For items for which no specification have been provided, vendor may follow their own specifications and prevailing international standards.

1.4 Cables

1.4.1 All cables shall have PVC insulated primary insulation of 85OC PVC as per IS-5831 Type C and inner and outer jacket shall be 90OC PVC to IS-5831 Type ST-2. Oxygen index of PVC shall be over 30% and temperature index shall be over 250OC.

1.4.2 When cables are required to be fire retardant, they shall be as per standard IEC 332 Part III Cat. A.

1.4.3 The insulation grade shall be 600 V/1100 V as a minimum and shall meet insulation resistance, voltage and spark test requirements as per BS -5308 Part-II.

1.4.4 All cables shall be twisted and armoured. Armour over inner jacket shall be of galvanized steel wire/flat as per IS-1554 part I.

1.4.5 For signal and control cables, inner jacket colour shall be black. Outer jacket colour shall be light blue for intrinsically safe application and black for others. For thermocouple extension cables the inner and outer jacket colour shall be as per IS-8784.

1.4.6 Maximum dc resistance of the conductor of the completed cable shall not exceed the following:

   a) 12.3 ohms/km at 20°C for cables with 1.5 mm² conductor.

   b) 39.7 ohms/km at 20°C for cables with 0.5 mm² conductor.

1.4.7 The mutual capacitance of the pair or adjacent cores shall not exceed 250 pF/m at a frequency of 1 kHz. The capacitance between any core and screen shall not exceed 400 pF/ m at a frequency of 1 kHz.

1.4.8 L/R ratio of adjacent cores shall not exceed 40 m microhenry/ohms for cables with 1.5 mm² conductor and 25 μH / 0 for cables with 0.5 mm² conductor.

1.4.9 The drain wire resistance including shield shall not exceed 30 ohms/km.
1.4.10 A pair of communication wire shall be provided for multipair cables. Each wire shall be 0.5 mm² of plain annealed single or multi-strand copper conductor with 0.4 mm thick 85°C PVC insulation. Insulation shall be green and red colour coded.

1.4.11 Vendor shall ensure a minimum of 20% of quantity of each type of cables supplied as spare including any special cable. And in each multipair cables 20% pairs shall be kept as spare.

1.4.12 Running length of the cable shall be printed at least at every 5 metre interval.

1.4.13 Signal Cables

a) Single pair shielded signal/alarm cables shall be used between field instruments/ switches and junction boxes/local control panels.

b) Multipair individually and overall shielded signal/alarm cables shall be used between junction boxes/local control panels and control room, in general.

c) The single pair shall be 0.5 m² conductor size, triad cables shall be 1.5 m² conductor size made of electrolytic copper conductor of 7’s strands with each strand of 0.53 mm diameter, multipair cables with 0.5 mm² conductor size shall have 16 strands of annealed electrolytic grade copper conductor with each strand of 0.2 mm diameter, multi triad cable or multi pair cable with 1.5 m² conductor shall have 7 strand with each strand of 0.53 mm diameter.

d) Shield shall be aluminium backed mylar/polyester tape bonded together with the metallic side down helically applied with either side having 25% overlap and 100% coverage. The minimum shield thickness shall be 0.05 m in case of single pair/triad and 0.075 mm incase of multipair/triad cable.

e) Drain wire shall be provided for individual pair and overall shield which shall be 0.5 mm² multi stranded bare tinned annealed copper conductor. The drain wire shall be in continuous contact with aluminium side of the shield.

f) All multi pair cables shall have 6 pair/12 pairs only while multitriad cable shall have 6 triads/8 triads only.

1.4.14 Control Cables

a) Single pair control cables shall be used between field mounted solenoid valves and junction boxes/local control panels and shall meet the requirements specified in para 1.4.13 above.

b) Multipair control cables shall be used between junction boxes/local control panel and control room mounted devices in general. These cables shall have only overall shielding.

c) These control cables shall have 1.5 sq mm conductor size with 7 stranded conductors of annealed electrolytic grade copper, with each strand of 0.53 mm diameter.

1.4.15 Fieldbus Cables

a) Fieldbus cables shall be 0.8 mm² twisted in pair individually and overall shielded with aluminium mylar tape with drain wire and armoured. Other parameters shall be as per Type A defined in IEC-61158-2.
b) Fieldbus cables shall be single pair, two pairs, three pairs and four pairs.

c) The field bus cable shall be field proven for FF applications.

1.4.16 Thermocouple Extension Cables

a) Single pair shielded thermocouple extension cables shall be used between thermocouple head and junction boxes transmitters/local control panel mounted instruments.

b) Multipair individually and overall shielded thermocouple extension cables shall be used between junction boxes and control room mounted devices.

c) The type of thermocouple extension cables shall be compatible with thermocouple used. In addition the colour coding of the primary insulation shall be as per IS-8784-1987 Table 5.

d) The cable shall have 16 AWG and 20AWG solid conductors for single and multipairs respectively.

e) All thermocouple extension cable shall be matched and calibrated in accordance with IEC-584-2.

f) Shield shall be aluminium backed by mylar/polyester tape bonded together helically applied with the metallic side down with either side having 25% overlap and 100% surface. Minimum shield thickness shall be 0.05 mm for single pair and 0.075 m m for multipair cable. Drain wire shall be 0.5 mm 2 multi-strand bare tinned annealed copper conductor. The drain wire shall be in continuous contact with the aluminium side of the shield.

g) Inductance shall not exceed 4 mH/Km. However for J-type thermocouple inductance could be 8 mH/km.

h) All multi-pair cables shall have 6 pairs/12 pairs only.

1.4.17 Power Supply and Other Cables

a) All power supply cables shall be as per IS-1554 Part I and shall have copper/aluminium conductors depending on conductor size. Minimum conductor size shall be 2.5 mm 5 of copper conductor. For higher sizes, aluminium conductor can be considered. All these cables shall be PVC insulated and armoured.

b) Any other special cable required for instruments shall also be supplied as per requirements. Vendor shall ensure that these cables are armoured type and shall meet all other requirements specified in para 1.4.1 through 1.4.12, as applicable.

1.5 Cable Glands

a) Vendor shall supply all cable glands required for glancing the above mentioned cables both at field instrument and local control panel side, junction boxes side and at control room side.

b) All cables glands shall be of nickel-plated brass and they shall be double compression type suitable for armoured cables.
c) Flame proof glands wherever required shall be supplied with Ex (d) certification.

d) Vendor shall supply a minimum of 20% of cable glands as spare.

1.6 Junction Boxes

a) Vendor shall supply junction boxes as per the cables selected, wherever required. These shall be of die cast aluminium alloy (LM-6) body and shall be weather proof, as a minimum.

b) These boxes shall have terminals suitable for minimum or 4mm² or less cable termination mounted on rails. 20% spare terminals shall be supplied in each junction box.

c) Telephone sockets and plugs shall be provided in junction boxes.

d) Flame proof junction boxes wherever required shall be supplied with Ex (d) certification. All such boxes shall be weatherproof also.

e) Each junction box shall have a minimum of 10% or 2 Nos., whichever is higher, spare entries. All spare entries shall be provided with plugs.

1.7 Junction Boxes for Fieldbus loops

1.7.1 For Fieldbus segment, junction box which is used for mounting the wiring/ terminal blocks to terminate the trunk and spurs in the fieldbus networks.

Unless otherwise specified, bidder must use the following type of terminal blocks:

For all FISCO signals : Weatherproof terminal blocks
For all FNICO signals : Non-incendive terminal blocks
For all safe signals : Weather proof terminal blocks
For all Explosion proof signals: Explosion proof/Flameproof terminal blocks

1.7.2 Junction box for Fieldbus field barrier concept:

Fieldbus junction boxes with field barrier assembly/ assemblies shall be provided. Housing shall be of SS316. Not more than 3 field barrier assemblies shall be considered in one segment. Field barrier assemblies in a segment shall be multidropped (shall not be daisy chained in a trunk). For multi field barrier assembly in a junction box. Field barrier assemblies shall be DIN rail mounted. Also bidder shall terminate the spare pair of trunk cable in DIN rail mounted terminal in junction box. One field barrier assembly shall contain:

- Isolation switch (EEEx de) for isolating the field barrier assembly from fieldbus trunk.
- Clamp on terminals (screw less type)
- Not more than 4 barriers / spur connections.
- Not more than one field device in each barrier / spur connection.
- Internal short circuit protection for each spur (short circuit current <= 50 mA)
- LED indicator for each spur short circuit.
- Each spur shall be galvanically isolated from trunk.
- Fieldbus terminator for each segment shall be inside junction box.
Each FF barrier junction box shall have provision to terminate addition part of trunk cable.

1.7.3 Not more than 3 wiring/terminal blocks shall be provided in each Fieldbus Junction Box.

1.7.4 The Fieldbus Junction Boxes shall be SS.

1.7.5 Sufficient spacing shall be provided inside the Junction Boxes for mounting of Megablocks, termination & routing of Trunk/Spur cables to the Megablocks, sufficient space shall be provided for installing terminator etc. inside the Junction Box.

1.7.6 For spur and trunk cables, 20% addition cable entries must be provided. Unused entries shall be plugged.

1.7.7 The cable entry shall be 1/2" NPTF. Each junction box shall be provided with sufficient entries with weatherproof, flameproof plugs, as required. Trunk entry shall be from the bottom whereas spur connection from the side.

1.8 Instrument Valves And Manifolds

a) Vendor shall supply instrument valves (miniature type) and valve manifolds wherever required.

b) Body rating shall be as per piping class or better. However trim material shall be SS304, as a minimum. All valves and manifolds shall be forged type only

c) Valve body and trim material shall be 316 SS unless otherwise specified. Superior trim material shall be selected as required by process conditions. Packing material in general shall be of PTFE.

d) Vendor shall supply a minimum of 20% instrument valves and manifolds as spare.

1.9 Impulse Piping/Tubing

a) Vendor shall supply 1/2" OD x 0.065" thick ASTM A 269 TP 316 L stainless steel seamless tubes as a minimum for impulse lines.

b) Where the pressure (operating) exceeds 70kg/cm²g or if piping is specified as impulse line, seamless pipes of size ½” NB of required thickness shall be supplied with material as per piping class.

c) Seamless tubes shall have a hardness of max 80 RB as typical.

d) Steam tracing shall be 10 mm OD copper tubes of electrolytic grade copper.

e) Vendor shall supply a minimum of 20% of pipe/tubes as spare.

1.10 Pipes And Tube Fittings

a) Vendor shall supply flareless compression type of tube fitting and of three piece construction with design similar to s wage lock/Parker Hannifen/Ermeto etc.b) The fitting/ferrule hardness shall be in the range of RB 85-90 so as to ensure a minimum hardness difference of 5 to 10 between tube and fittings. The ferrule shall be of stainless steel material, in general.
c) Socket-weld type forged pipe fittings of suitable material and rating shall be supplied for pipe fittings. The minimum rating shall be 3000 Lbs. Weld neck fittings shall be used where socket weld type are not allowed by piping class.

d) Instrument air brass fittings shall be suitable for use on copper tubes conforming to ASTM B 68/B 68 M hardness not exceeding RB 50. All fitting parts shall be manufactured from Brass as per IS -319 bar stock or equivalent and shall be nickel plated.

e) All threaded fittings shall have NPT threads as per ANSI/ASME B16.11 only.

f) Vendor shall supply a minimum of 20% of each type of pipe/tube fittings as spare.

1.11 Pneumatic Signal Tubes

a) Vendor shall supply 6mm OD x 1mm thick PVC covered fully annealed electrolytic grade copper tubes as per ASTM B68.74A Cu. No.122 (DH) for pneumatic signal tubes.

b) Vendor shall avoid use of intermediate connections and shall estimate single length for each instrument location.

c) Vendor shall supply a minimum of 20% length of these tubes as spares.

1.12 Instrument Air Lines Fittings And Valves

a) Seamless galvanised, inside and outside, carbon steel pipes used for instrument air distribution shall be as per IS 1239 class Heavy.

b) Galvanised forged screwed carbon steel screwed fittings of 2000 lbs rating fittings shall be used.

c) Isolation valves on instrument air service shall be packless gland type full bore ball valves.

d) Vendor shall supply a minimum of 20% of air pipe, fittings and valves as spare.

1.13 Air Filter Regulators

a) Instrument air filter regulator of suitable size, range and capacity shall be supplied for each pneumatic instrument.

b) The body of the filter shall be anodised aluminium.

c) The filter shall have 5 m micron sintered bronze/ceramic filter element and shall be provided with manual drain and 2” nominal size pressure gauge.

d) Vendor shall supply a minimum of 20% of air filter regulators of each size and range as spare.

1.14 Cable Trays and Cable Ducts
a) All cables on the main pipe rack shall be laid in cable duct. Cable ducts shall be fabricated as per 'Duct Fabrication Details' standard No. 7-52-253.

b) All branch cables/tubes shall run on cable trays

c) These cable trays shall be made out of galvanised mild steel sheets of 2.5 m thickness. Ladder trays shall be of mild structural steel and shall be painted with redoxide primer. 50 mm x 50 mm angle shall be used as a minimum.

d) The width shall be so selected that 50% of tray space is available for future use.

e) Suitable cable clamps shall be supplied for binding the cables/tubes at every 500 mm.

1.15 Instrument Support/Structural Steel

a) Vendor shall supply instrument stands, stanchions and other structural steel material required for supporting the cable trays, impulse lines and instruments.

1.16 HEAT TRACING AND INSULATION

a) Heat tracing and insulation of line mounted instrument, instrument impulse lines shall be carried out as per line specifications. Similar philosophy shall also be followed for equipment mounted instruments.

b) Instruments mounted on jacketed lines and jacketed equipments shall be jacketed only. In case the jacketing of any particular instrument item is not possible, heat tracing may be selected after intimation to Owner/Owner Representative before proceeding ahead.

c) For all steam traced lines and steam jackets, a suitable type of steam trap must be provided for proper and efficient tracing. Separate dedicated steam trap shall be used for each instrument. Steam trap shall preferably be located on ground level with its outlet connected to drain funnel or as advised elsewhere in the package.

d) Wherever electric tracing is shown in the approved P&ID and selected for instruments and instrument lines, this must be suitable for the line temperature rating.

e) Steam tracing shall be avoided inside any room/ or shelter. The heat tracing required for analyzers shall be carried out by electrical tracing using prefabricated tube tracers.

f) Insulation of all in-line instruments like control valves, safety valves etc. shall be done as per the line requirements. Also all direct equipment mounted instruments like level gauge, displacer/float type instruments etc. shall be properly insulated as per insulation requirements of the equipment on which these are installed.

g) The insulation with 25 mm dia. Sodium silicate inhibited ceramic fiber rope (fiber glass / SS wire braided) by spiral winding in position, wrapping the rope around piping so as to cover the piping completely without leaving any gap, application of two layers of self adhesive aluminum foil tape (min 0.1 mm thick) spirally wound over the rope surface with the joints in two layers staggered. Ceramic fibre rope shall be of minimum density 250 kg/m³ shall be made up of ceramic fibre insulation with other properties of ceramic fibre rope confirming to 3.2.3 (1) of specification “6-44-0002 for hot insulation” work.

2.0 INSTALLATION
2.1 Vendor shall be completely responsible for installation of all instruments within their battery limit, in line with the installation standards (typical) furnished alongwith this specification. 2.2 Whenever installation is beyond the scope of vendor/contractor, purchaser shall install the instruments as per the detail ls/documents/drawings provided by the vendor/contractor. However, in such a case it must be ensured that complete installation materials shall be supplied.

2.3 All direct mounted instruments like thermocouples thermowells, temperature gauges, pressure gauges, pressure switches etc. shall be installed in such a way that they have good readability and accessibility.

2.4 The capillary of all capillary type instruments shall be supported properly and shall be protected against mechanical damage.

2.5 All pressure/differential pressure instruments shall be provided with block and bleed/bypass, drain/vent valves etc as per the installation standards, and shall have accessibility.

2.6 All primary piping/tubing (impulse lines) shall have a slope of 1 in 12 on the horizontal run.

2.7 All welding shall be carried out as per the relevant codes with proper electrodes. Any testing (non destructive) like D.P. test and radiography on root weld and final weld shall be carried out as applicable. All consumables shall be par 1 of vendor's scope of supply. Any pre/post weld treatment as required by the relevant codes shall be carried out.

2.8 All threaded joints shall be joined by PTFE tapes only.

2.9 All impulse lines shall be supported at regular intervals.

2.10 Instrument drain/vent connections shall be piped to safe area like oily water sewer or above pipe racks to avoid accumulation of hazardous fluid in the plant atmosphere.

2.11 Steam tracing wherever required shall be carried out by 10 mm OD x 1 mm thick copper tubes and condensate traps shall be provided to collect all the condensate and shall be piped to the nearest pipe drain funnels.

2.12 All tubes/cables shall be properly laid on cable trays, which shall be supported at regular intervals.

2.13 Separate routing or physical separation shall be maintained between signal cables, shut down and power cables.

2.14 Wherever intrinsically safe system cabling is employed, the minimum separation of 150 mm shall be adhered between IS (intrinsically safe) and non IS signal cables.

2.15 The cases of instruments shall be earthed by earthing wire to the nearest earth bus bar for safety reasons.

2.16 In case the cables are to be buried or laid in concrete trench the same shall be carried out by vendor. In case civil work is carried out by purchaser, requirement of trenches shall be provided with prior intimation to client.

2.17 Painting of cable trays/ducts, mild steel cable trays, angle trays, instrument supports and all structural supports shall be painted as under :-
a) The surface to be painted shall be thoroughly cleaned with brush sand paper to remove all scales. After cleaning, one coat of red oxide zinc chromate primer shall be given conforming to IS -2074 and allowed to dry. One coat of final when paint shall be applied.

Second and final coats of paint of final colour shall be given before handing over the plant/commissioning.

2.18 Installation of Systems (DCS, PLC, Analysers etc.)

2.18.1 The system shall be installed by the system vendor who would be responsible for installation and termination of interconnecting cables in the system racks/cabinets. All interconnecting cables shall be identified and the individual cores/wires shall be properly identified using ferrules. Direct-cross ferruling method shall be used for identification.

2.18.2 All system communication cables shall be layed in covered GI (galvanised iron) trays away from power cables. Prefabricated cables shall be avoided for interconnection if these are to be routed outside the cabinets. If unavoidable these should be laid in covered GI trays.

2.18.3 All panels/cabinets shall be properly levelled and secured firmly with the base supporting structure. However, the consoles and printer stands need not be secured to base structure.

2.18.4 Grounding

a) Each cabinet, console and other equipment supplied as a part of system shall have earthing lugs which shall be secured to the 'AC mains earthing bus'.

b) All circuit grounds, shields and drain wires shall be connected to the 'system ground' bus which is isolated from 'AC mains earth'. This bus shall typically be 25 mm wide and 6 mm thick of copper. The total resistance of system ground shall be less than 5 ohms unless otherwise recommended by system manufacturer.

c) Safety barriers, if used, shall be secured to 'Safety ground' which shall have typically ground resistance of less than 1 ohm. The bus shall be designed considering a fault level of 0.5 A at 250V r.m.s. per barrier.

2.18.5 All other installation guidelines as recommended by system manufacturer shall be followed.

3.0 TESTING AND CALIBRATION

3.1 All impulse lines shall be tested hydrostatically at 1.5 times the maximum operating pressure. Ensure that instrument and vessel/piping is isolated during this test.

3.2 In case of special instruments/items where hydrotesting is not permitted due to service conditions, the impulse lines testing shall be carried out by using air or nitrogen.

3.3 All external cage type level instruments shall be tested upto 1.5 times operating pressure by using nitrogen only.

3.4 After pressure testing, all these impulse lines shall be drained and dried with dry air to remove any traces of moisture, oil and dust.

3.5 Instrument air lines shall be duly tested for any leak after pressurising and isolating the main root valve by soap solution. After isolation, the rate of fall in pressure shall be less than 1 kPa for every 4.4 metre (1 psi for each 100 feet) of copper tubing for a test period of 2 minutes.
3.6 Pneumatic signal tubes shall be flushed and tested with instrument air for any leak at a pressure of 1.5 kg/cm² g. After pressurising the line, the source of pressure is cut off and rate of fall in pressure shall be less than 1 kPa for every 4.4 metre (1 psi for each 100 feet) of tubing for a period of 2 minutes.

3.7 All instrument cables shall be tested for continuity and insulation. While meggering the cables for insulation testing, ensure that all instruments and barriers are isolated at both ends.

3.8 All instruments supplied by the vendor shall be calibrated using proper test equipment.

3.9 All instruments shall be calibrated for 0%, 25%, 50%, 75%, 100% and vice versa (Refer Note).

3.10 All temperature gauges shall be calibrated using temperature baths.

3.11 All thermocouple activated instruments shall be calibrated by generating millivolts by a potentiometer.

3.12 All transmitters shall be calibrated as per instrument ranges.

3.13 All displacer type level transmitters shall be calibrated with water or suitable fluids and corrected for specific gravity.

3.14 All alarm and trip switches shall be calibrated over the entire range and finally set and checked for alarm/trip points and reset points as per the alarm/trip set point schedule. After setting, these shall be sealed.

3.15 All control valves, prior to stroke checking, shall be externally cleaned thoroughly. The full stroke of valve shall be checked for opening and closing. Any adjustment required for obtaining full stroke and reducing hysteresis shall be carried out. The hysteresis shall not be more than 1% URV (upper range value) with positioners and 5% URV without positioners.

3.16 Bubble tight shut-off control valves and shut down valves shall be checked for seat leak test and gland leak test.

3.17 Solenoid valve shall be checked functionally for its operation.

3.18 Safety valves and relief valves shall be set/tested by using dry air/nitrogen. Leakage if any shall be removed by proper lapping of seat and disc.

3.19 All electronic/pneumatic receiver instruments shall be calibrated as per the manufacturer's instructions. Controllers shall be aligned properly.

3.20 All special instruments like analyzer shall be checked and calibrated as per manufacturer's instructions. Prior to testing, all analyzer sample lines shall be thoroughly cleaned by carbon tetrachloride or any other cleaning liquid. After cleaning, these lines shall be thoroughly purged with dry nitrogen.

3.21 No oil should be used in oxygen and chlorine service lines.

3.22 The accuracy of overall loop shall be within "1% for electronic and "1.5% for pneumatic loops.

3.23 After performing the calibration of all instruments, the entire loop shall be checked for proper operation.

Note: Calibration sheet for each calibrated instrument to be duly filled, signed & counter signed by PMC.
3.24 The entire shutdown scheme shall be simulated from the process trip switches and the scheme shall be tested for its proper operation prior to start up of the unit.

3.25 If no instrument air is available vendor shall provide necessary N2 cylinders to carry out the above activity.

3.26 Testing Of Systems (DCS, PLC etc.)

3.26.1 All the system functions shall be checked thoroughly for proper functioning. These shall include but not limited to the following tests:

   a) Visual and mechanical.
   b) Complete system configuration loading.
   c) Demonstration of all system functions.
   d) Checking of all systems displays.
   e) Checking of correct functioning of all keyboards.
   f) Demonstration of all system diagnostics.
   g) Checking of proper functioning of all printers, hardcopy unit, and printing of all reports.
   h) Checking of all disc drives.
   i) Complete checking of logic system, loading of user's program and checkout of results.
   j) Checking of correct changeover of the back-up/redundant units in case of failure of main units.

3.26.2 The input signals shall be simulated by disconnecting the field wires for all inputs. Wherever control room mounted Transmitters/Converters/Receiver switches are used, the functioning of same shall also be checked.

3.27 Loop Checking

3.27.1 Loop checking shall be carried out by vendor, which shall include proper functioning and interconnection of all items in the loop.

3.27.2 All input signals shall be generated in the field and corresponding reading shall be checked at all corresponding displays. All the outputs shall be checked in the field, by physical verification of valve stroke or operation of solenoid valve/pick-up of electrical contactor.

3.27.3 After loop checking is completed vendor shall connect back any terminals and connections removed during loop checking.

3.27.4 For fieldbus loops the segment verification shall be carried out by DCS vendor. Any field side modifications required shall be carried out by bidder

4.0 COMMISSIONING

4.1 This activity shall be carried out in a systematic manner so as to avoid any accident to plant and operating personnel.
4.2 During the plant start up all the instruments calibration, controller alignment, trip point settings shall be trimmed so as to meet the operation requirements.

4.3 Prior to guarantee run of any package unit, the vital instruments as required by vendor have to be recalibrated and the results recorded.
STANDARD SPECIFICATION
FOR
INSTRUMENTATION WORK

07.03.2011 07.03.2011 For Tender SKPradhan /HSaini SanjayKrTripathi SanjayKr Tripathi
REV REV DATE EFF DATE PURPOSE PREPD REVWD APPD
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1. GENERAL

1.1.1 Scope

This specification together with the attachments covers the design, engineering, supply, factory inspection and testing, field testing and calibration, installation and commissioning of instrumentation and control systems on a turnkey basis for its successful operation.

1.1.2 The detailed scope of work, specific job requirements, design basis, exclusions, deviations, additions etc. are indicated elsewhere in the bid document.

1.1.3 This specification provides only the qualitative specifications of commonly used instruments and systems, but by no means covers the specification of each and every item covered in the bid document. Instruments specification for those items not covered in this specification shall be submitted by the contractor for approval.

1.1.4 Contractor shall be fully responsible for design, material selection, sizing and proper selection of the instruments and systems being supplied by them. Any approval or comment on any document or guideline issued to contractor before or after placement of contract or during execution of the contract shall not absolve the contractor of their contractual obligations and responsibility with regards to completeness, proper selection, satisfactory operation and easy maintenance of the unit.

1.1.5 All equipments supplied shall be of field proven quality both with respect to design and materials: Prototype instruments or instruments of an experimental nature shall not be offered or supplied.

In general, all instruments and instrument control systems, like Programmable Logic Controller (PLC), Distributed Control System (DCS), Analyser Systems, Gas Detection Systems, etc. offered by contractor shall have a well proven performance record of operating satisfactorily in the hydrocarbon industry like refinery, petrochemical, gas processing etc. for a minimum of 4000 running hours.

No instrument requiring special maintenance or operating facilities shall be offered or supplied as far as possible.

In the event of any conflict between this specifications, data sheets, related standards, codes etc., the contractor shall refer the matter to the purchase/purchaser's representative for clarification and only after obtaining the same should proceed with the manufacture/engineering of the item in question.

1.2 Bids

Bidder shall clearly define the operational philosophy suggested by them, in line with requirements specified in the tender specifications. Bidder shall also clearly indicate the provision of control panels, and control systems required for their sub packages offered by them.

1.2.2 Bidder shall provide the following information alongwith their offer as a minimum:

a) Compliance statement as given in bid document

b) Configuration diagram and details of the offer ed. control systems like Distributed Control System, Programmable Logic Controller, Analyser system, CCTV, Gas Detection System etc.
c) Details of special instruments and control systems if any.

d) List of deviations, if any, from bid package clause number wise with reasons thereof, wherever applicable.

1.2.3 Information like Instrument list and typical specifications if enclosed by bidder in their bid, shall be retained for information only and shall not be referred by bidder as contractual agreement No implication shall be admissible on the basis of these documents. Contractor shall submit details only after the finalisation of P&ID (piping and Instrument Diagram).

1.2.4 In addition to mandatory spares and consumable spares indicated elsewhere in the tender document, bidder shall also quote for two years operational spares’ for all the instruments and control systems including those required for sub packages being offered by them.

1.3 Applicable national/international standards.

Design and terminology shall comply, as a minimum, with the latest edition prior to the date of purchaser's enquiry with following codes, standard practices and publications:-

AGA American Gas Association
Report No.3 - Orifice Metering of Natural Gas & other related hydrocarbon fluids
Report No.9 – Measurement of Gas by Ultrasonic Meter

ANSI/ASME American National Standards Institute/American Society of Mechanical Engineers.
B 1.20.1 Pipe Threads General Purpose (Inch)
B 16.5 Pipe Flanges and Flanged Fittings
B 16.20 Metallic Gaskets for pipe Flanges, Ring Joint, Spiral wound and Jacketed.
ANSI /ISA - S 7.3 Quality standard for instrument air
ANSI MC 96.1 Temperature measurement thermocouples
ANSI/ISA - S 5.115.3 Instrumentation symbols and identification
ANSI/ISA S 75.01 Flow equations for sizing control valves
ANSI B40.1/ASME Gauges and Pressure Indicating Dial Type Elastic Element
ANSI/ASME B16.36 Orifice Flanges

ANSI/FCI American National Standards Institute/ ANSI B16.104 Fluid Control Institute
70.2 Control valve seat leakage classification

API American Petroleum Institute
API 520 Sizing, selection and installation of pressure relieving devices in refineries.
Part-I - Sizing and selection
Part-II - Installation
API 521 Guide for pressure relieving and depressurising systems.
API 526 Flanged steel Pressure Relief Valves.
API 527 Seat tightness of Pressure Relief Valves.
API MPMS Manual of Petroleum measurement standards.
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
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<tr>
<td>API RP 551</td>
<td>Process Measurement Instrumentation</td>
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<td>API S 1101</td>
<td>Measurement of Petroleum Liquid Hydrocarbon by Positive Displacement meter.</td>
</tr>
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<td>API S 2000</td>
<td>Venting Atmospheric and low-pressure storage tank nonrefrigerated and refrigerated.</td>
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<tr>
<td>API S 2534</td>
<td>Measurement of liquid hydrocarbons by turbine meter systems</td>
</tr>
<tr>
<td>API S 670</td>
<td>Vibration, Axial-Position and Bearing-Temperature Monitoring Systems</td>
</tr>
<tr>
<td>API RP 550</td>
<td>Manual on installation of refinery instruments and control system</td>
</tr>
<tr>
<td>API RP 551</td>
<td>Process Measurement Instrumentation</td>
</tr>
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<td>API RP 552</td>
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<td>API RP 555</td>
<td>Process Analysers</td>
</tr>
<tr>
<td>API RP 557</td>
<td>Guide to Advance Control Systems</td>
</tr>
<tr>
<td>API RP 554</td>
<td>Process Instrumentation &amp; Control</td>
</tr>
</tbody>
</table>

**ASME**
- American Society of Mechanical Engineers
- ASME Sec-VIII Boiler and Pressure Vessels Code rules for construction of pressure vessels
- ASME Sec-I Boiler and Pressure Vessels Code. Section-I ‘Power Boilers’
- ASTM E 230 EMF tables for standardized thermocouples
- ASTM E 608 Standard specification for metal-sheathed base-metal thermocouples
- ASME B16.10 Face-to-Face and End-to-End Dimensions of Valves
- ASME B16.47 Large Diameter Steel Flanges (NPS 26 thru NPE 60)
- ASME B16.5 Pipe Flanges and Flange Fittings (for steel,
  ASME Boiler and PresSure Vessel Code: Part VIII ‘Unfired Pressure Vessels’

**BIS**
- Bureau of Indian Standards

**BS**
- British Standards
  - BS-5308 Part-II :Specification for PVC insulated cables.
  - BS-7244 Flame Arrestors.
  - BS 3463 Observation and Gauge Glasses for Pressure Vessels

**DIN**
- German Standards
  - DIN-43760 Temperature Vs Resistance curves for RTDs.
  - DIN-19234 Electrical Distance Sensors; DC interface for Distance Sensor and Signal Converter.

**EN-10204**
- Inspection Documents for Metallic Products

**IBR**
- Indian Boiler Regulations
IEC

International Electro technical Commission
IEC 60079 Electrical Apparatus for Explosive Gas atmosphere
IEC 60085 Thermal Evaluation and Classification of Electrical Insulation.
IEC 60332 Test on bunched wires or cables.
Part III Cat. A
IEC 60529 Degree of protection provided by enclosures. (IP code)
IEC 60534-2 Industrial Process Control Valves - Flow capacity.
IEC 60534-2 Thermocouple Tolerances
IEC 60751 Industrial Platinum Resistance Thermometer Sensors
IEC 61000-4 Electromagnetic compatibility for Industrial Process measurement and control equipment.

IEC-61508 Defines safety integrity levels
IEC 60079 Code of Practice for the Selection, Installation and Maintenance of Electrical Apparatus for use in Potentially Explosive Atmospheres
IEC 60529 Degrees of Protection provided by enclosures
IEC 60534.2.5 Flow capacity - Sizing equations for fluid flow through multistage control valves with interstage recovery
IEC 60534.1 Control valve terminology and general considerations
IEC 60534.2.1 Flow capacity - Sizing equations for fluid flow under installed conditions
IEC 60534.2.3 Flow capacity - Test procedures
IEC 60534.2.4 Flow Capacity - Inherent flow characteristics and rangeability
IEC 60534.3.1 Face-to-face dimensions for flanged, two-way, globe-type, straight pattern and centre-to-face dimensions for flanged, two-way, globe-type, angle pattern control valves
IEC 60534.3.2 Face-to-face dimensions for rotary control valves except butterfly valves
IEC 60534.8.3 Industrial Process Control Valves - Aerodynamic Noise Prediction
IEC 60534.8.4 Industrial Process Control Valves – Prediction of Noise Generated by Hydrodynamic Flow
IEC 60584 Thermocouples
IEC 60751 Industrial Platinum Resistance Thermometer Sensors
IEC 61000.4.1 Testing and Measurement techniques- Overview
IEC 61000.4.3 Testing and Measurement techniques - Radiated, Radio Frequency, Electromagnetic Field Tests
IEC 61000.4.4 Testing and Measurement techniques- Electrical Fast Transient/burst Immunity Tests
IEC 61000.4.5 Testing and Measurement techniques – Surge Immunity
IEC 61508 Functional Safety of Electrical, Electronic, Programmable Electronic Safety Related Systems
IEC 61511 Functional Safety of Safety Instrumented Systems for the Process Sector

IEEE

C37.90.1 - 2002 Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems

IS

Indian Standard
IS-5 Colours for ready mixed paints and enamels
IS-319 Specification for free cutting Brass bars, rods and sections
IS-1239 Mild steel tubes, tubulars and other wrought steel fittings.
IS-1271 Specification of Thermal Evaluation and Classification of Electrical
Insulation
IS-1554 PVC insulated (heavy duty) electric cables working
   Part I - voltage up to and including 1100V
IS-2074 Ready mixed paints, air drying, red oxide - zinc chrome
IS-13947 Degree of Protection provided by Enclosures for Low Voltage Switchgears
IS-2148 Flame proof enclosures for electrical apparatus for Explosive Gas
   Atmospheres – Flameproof Enclosures ‘d’.
IS-3624 Specification for pressure and vacuum gauges
IS-5831 PVC insulation and sheath of electric cables.
IS-7358 Specifications for Thermocouples
IS-8784 Thermocouple compensating cables.

ISA
   Instrumentation, Systems and Automation Society
   S-5.2 Binary logic diagrams for process operations.
   S-7.3 Quality standard for instrument air
   S-75.01 Flow equations for sizing control valves
   ISA 18.1 Annunciator sequences and Specifications
   ISA S84-01-1996 Application of Safety Instrumented Systems in the Process
      Industries
   ISA5.2 Binary Logic Diagrams for Process Operations

ISO 5167
   Measurement of fluid flow by means of orifice plates, nozzles and venturi
   tubes inserted in circular cross-section conduits.
ISO 4266: 1994 Petroleum and liquid petroleum products- Measurement of
   temperature and level in storage tanks-Automatic methods
ISO 5208 Pressure Testing of Valves

NACE
   National Association of Corrosion Engineers
   NACE MR0175 ISO 15156 Petroleum & Natural Gas Industries – Material for Use H2 S-
      Containing Environments in Oil & Gas Production
   NACE MROI03-2007 Instruments used in Sour-environment

NEC
   National Electric code

NEMA
   National Electrical Manufacturer's Association

ICS-6
   Enclosures for Industrial control and systems.

NFPA
   National Fire Protection Association
   NFPA-496 Purged and pressurized enclosures for electrical equipment.
1.4 Drawing and Data

1.4.1 Detailed drawings, documents, data and catalogues etc. as required from the Contractor have been indicated separately in the Contractor Data Requisition. The required number of reproducible and prints should be despatched to the address mentioned, adhering to the time limits indicated.

1.4.2 Bidder shall furnish all documents in A4: Size (210 mm x 297 mm) paper or folded in A4 size unless otherwise specified. All drawings and sketches shall be in multiples of A4 size like A3 (297mm x 420 mm) or A2 (420 mm x 594 mm) etc., but folded to 'A4' size. Final documentation shall be submitted in bound volumes.

1.4.3 Definitions of Deliverable Documents

1.4.3.1 Instrument work Specifications

This document details out the procedures and methodologies adopted by the contractor to carry out complete instrumentation work. The document- apart from others shall include:

a) Agencies involved for carrying out design, detailing, engineering, procurement, installation, loop checking and commissioning of Instrumentation with specific reference to various systems.

b) Scope of work and responsibilities of various agencies involved.

c) Interface requirement and co-ordination between various agencies.


e) Experience of various agencies in carrying out respective jobs.

f) Inspection & testing requirements and co-ordination procedures for the same.

g) Co-ordination requirements & procedures for co-ordination, with outside/ statutory authorities.
h) Quality control and assurance procedures to ensure proper quality.

1.4.3.2 Drawing and Document Schedule

This document lists out drawings and documents prepared and/or submitted by contractor to owner either during engineering or as a part of final documentation. Following information shall be available in this document:

a) Name and number of each drawing and document listed.
b) The schedule for the document submission, contractor shall follow as per the overall schedule.

1.4.3.3 Instrument Index

Instrument Index lists out all instruments those appear on the P&ID without any exception. It is a basic instrument document which is necessary for the smooth execution of a job and is also a reference document after the completion of job. Instrument Index shall be prepared in blank format attached. In case, any other format is used, it must contain all information as listed in this format.

1.4.3.4 Sub Vendor List (for Instruments and Accessories)

Separate sub-vendor list is included elsewhere for instrumentation item. The list provided are for make only and not for model number. It is contractor's responsibility to select correct model number to suit the requirements and has requisite proven track record. It may be possible that make and/or model number of some instruments are identified in licensor's process package or in P&IDs, in such cases licensor process package or P&ID shall be guiding. In case for certain instruments vendor list is not included, suggested vendor list will have to be got approved from the purchaser/purchaser's representative.

1.4.3.5 Instrument sizing calculations, selection requirements

Instrument sizing calculations provide information regarding sizing (as per standards specified elsewhere in this document), type, selection and other related information.

Following sizing calculations shall be applicable, in general duly approved by the authority indicated in Vendor's Standard Quality Plant

a) Control valve and desuperheater sizing including noise calculations.
b) Safety valves/pressure relief valves/pilot operated pressure. relief valves/rupture disc sizing.
c) Flow element sizing including orifice plates, averaging pitot-tubes. venturi, flow nozzle etc. and selection.
d) Sizing for self actuated control valve.
e) Utility consumption calculation including power supply (UPS (Uninterrupted Power Supply/ Non UPS) Instrument air, stream for tracing etc.
f) Cable size calculations for power cables.
g) Calculation for intrinsically safe loop for proper selection considering various entity parameters.

h) Analyser sample transportation time calculations.

i) Control system calculations, like scan time, communication bus loading, response time etc.

1.4.3.6 Utility Requirements

This document lists out the following information regarding utilities required by the contractor:

a) List of utilities required i.e. Power (UPS, Non UPS). Instrument air, Cooling water, Steam for tracing, Nitrogen etc.

b) Location and estimated/actual requirement at each location. The requirement shall be listed as minimum/normal/maximum.

c). In case of AC power, the In-rush current with duration and power factor shall also be indicated for each location.

1.4.3.7 Nozzle Elevation Drawings for Level Instruments

These drawings represent the nozzle elevation, nozzle sizes and rating, requirement of stand-pipes, type of level instrument etc. for all the vessels, columns, exchangers and tanks.

1.4.3.8 Purchase Requisition (PR)

Purchase Requisition contains all information which form part of material requisition but updated in line with the finally accepted offer of the successful bidder. Typically purchase requisition shall contain

a) Instrumentation specification, detailed instrument data sheets

b) Standard specification, quality assurance requirements

c) Testing (shop and field). inspection and shipping requirements

d) Drawing document requirement

e) Training requirements, if applicable

f) Make and Model number of selected vendor.

1.4.3.9 Functional Schematics (FS)

Functional Schematics details out the functionality of all the loop’s shown on the P&ID including their correlation. The schematic shows all the hardware necessary to configure a loop including their physical location, their interconnection and important software blocks as applicable to make a loop complete. Similar loops may be combined under the same - functional schematic.

1.4.3.10 Logic Diagrams

Logic diagram is a logic representation of process interlock and shutdown system and details out the functionality, in a schematic form, based on either process cause and effect table shown on the P&ID or in a separate write-up. The schematic shall be prepared based on ISA S5.2 - "Binary Logic
Diagrams for Process Operations* and shall show the physical location of Input / Output devices, their interconnection with functional blocks, bench status of all electrical devices etc. The schematic shall also be supplemented with operational requirements like startup and process bypasses, reset and shut down push buttons, selector switches, status lamp etc.

1.4.3.11 Instrument Loop drawings

Each loop shall have a separate Instrument Loop drawing which shall show each component from field device to final receiver including physical location, initiating device, its terminal number, junction box with its terminal number, cable number with pair number/polarity, receiver instrument terminals/cabinet terminals, system functional blocks of loop in simplified manner (without configuration details).

1.4.3.12 Control Room Layout

Control room layout drawing shall show the location of control panels: system cabinets, marshalling racks and other auxiliary/ cabinets, consoles with monitors, hard wired, consoles, printers, non-system panels/cabinets including panels/cabinets for packages, LEL panel, fire alarms panels or any other equipment required to be installed in control room. The layout shall be prepared on control room architectural drawing, and shall also show layout of equipment in engineering room/computer room etc. CCTV layout shall also be shown. In case of satellite rack room, a separate drawing shall be prepared.

1.4.3.13 Analyser Room / Shelter Layout

Analyser Room / Shelter drawing shall show the location of all analyzers, sample handling systems, junction boxes, HVAC system warning panel, CRTs / analyser consoles, if any and any auxiliary rack / panel / cabinet to be located in the analyser room / shelter along with complete dimensions. The drawing shall also show location of light fittings (inside and outside the shelter/room), LEL detector and fire detectors as applicable. A separate drawing with dimensions shall be issued for each analyser room/shelter.

1.4.3.14 Panel Front Arrangement

This drawing shall show the arrangement of panel mounted instruments like indicating instruments, alarm annunciator, indicating lamps, push buttons/switches etc. including their approximate sizes and their mounting locations.

1.4.3.15 Configuration Diagram

This drawing is a graphical representation of all major hardware required in a configurable control system which are necessary to meet all the expected functional requirements.

1.4.3.16 Dynamic Graphic Display Drawings

These drawings provide a graphic representation of P&ID's arranged in a sequence which when displayed on the CRT, shall provide easy and logical operational views.

1.4.3.17 Input / Output Assignment

This document indicates the physical assignment of various I/O modules 0 and their respective channels to various physical inputs and outputs.
1.4.3.18 Instrument Duct/Tray /Trench Layout

Instrument duct/tray layout drawing show the routing of main instrument duct/tray o layout in the unit/plant. The drawing shall be prepared on plot-plan and shall show the size, cross-section at various locations, general notes, symbols, reference drawings and the control room entry.

1.4.3.19 Instrument Location Plans

Instrument Location Plans shall show the location of instruments, location of tapping points, location of local panels, junction boxes, main cable routes (cable duct / trenches), instrument air distribution scheme etc. These drawings are prepared on equipment layout drawings preferably in 1:50 scale.

1.4.3.20 Instrument Cable Schedule

The instrument cable schedule shall show all instrument and power cables required for complete instrumentation. The document shall show, tag number, cable number, type, length and size of cables, type of junction box, identity of local panel, control room panel/cabinet location etc.

2. DESIGN PHILOSOPHY

2.1 Instrumentation shall be complete in every respect and liberal to the extent of providing data on all operations and variables sufficient for the state, efficient and easy operation, start up and shut down of the plant.

2.2 The design and installation of instruments shall be generally in accordance with ISA / API recommended practices and other applicable standards like BIS, IBR etc. Material specifications and practices shall, in general, conform to appropriate ASTM or equivalent standards. All standards and code of practice d o herein shall be of the latest edition prior to the date of purchaser’s enquiry.

2.3 All instruments and equipments shall be suitable for use in a hot, humid and tropical industrial climate in which corrosive gases and chemicals may be present. As a minimum, all instruments and enclosures in field shall be dust proof *and weatherproof to IP-55 as per IEC-529/IS-2147 and secure against the ingress of fumes, dampness, insects and vermin. All external surfaces shall be suitably treated to provide protection against corrosive plant atmosphere.

2.4 Instrument Requirements for classified area

2.4.1 a) All electronic/electrical instruments and equipments shall be suitable for area classification as per IEC codes and shall be tested by any recognised authority like BASEEFA, FM, PTB, CMRI etc. and shall be certified by CCE.

b) Certified Intrinsically Safe (IS) equipment as per IEC-79-11** shall be used, in general, in hazardous area. In case intrinsically safe equipment is not available, flameproof enclosures as per IEC-79.01 may be considered.

c) Junction boxes and accessories required for flameproof instruments shall also be certified flameproof.

d) All non flameproof panels and cabinets installed in classified area shall be purged as per requirements specified in NPPA-496, as a minimum.

e) Other type of protection as specified in IEC-79 shall not be used.
2.4.2. Statutory Approvals

a) Contractor shall be responsible for obtaining all statutory approvals, as applicable for all instruments and control systems.

b) In addition, equipments/instruments/systems located in the hazardous area shall be certified by the local statutory authorities for their use in the area of their installation. In general following certification shall be given:

- For all intrinsically safe/explosion proof/flameproof equipments/instruments/systems or equipments with any other type of protection allowable as per this package which are manufactured abroad and certified by any statutory authority like BASEEFA, FM, UL, PTB, LCIE etc. should also have the approval of Chief Controller of Explosives (CCE), Nagpur.

- For all flame proof equipments manufactured locally (indigenously), the testing shall be carried out by any of the approved test house like CMRI/ERTL etc. The equipment shall in addition bear the valid approval from Chief Controller of Explosives, Nagpur and a valid BIS license.

- For all intrinsically safe equipment manufactured locally (indigenously), the testing shall be carried out by any of the approved test house like CMRI/ERTL etc. The equipment shall in addition bear the valid approval from Chief Controller of Explosives, Nagpur.

c) Approvals other than above shall neither be offered nor these will be acceptable.

2.5 Sizing for control valves, desuperheaters and safety valves is contractor's responsibility. In the P&ID and some cases in data sheets, valve sizes are identified. Contractor shall size these valves also. It is contractor's responsibility to supply the items as per approved sizes. For orifice-the sizing shall be carried out by contractor and in case due to these sizing the line sizes need to be increased or decreased the same shall be carried out by the contractor as part of his contract.

b) The type of flow instruments shall be decided by the contractor based on technical specifications and shall be approved by the purchaser/purchaser's representative.

In general type as indicated in P&ID/by licensor shall be followed.

2.6 Following units of measurement shall be applicable, unless indicated specifically otherwise:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>m³/h</td>
</tr>
<tr>
<td>Liquid</td>
<td></td>
</tr>
<tr>
<td>Steam</td>
<td>kg/h</td>
</tr>
<tr>
<td>Gas and Vapour</td>
<td>Nm³/h</td>
</tr>
<tr>
<td>Pressure / Vacuum</td>
<td></td>
</tr>
<tr>
<td>Gauge</td>
<td>kg/cm²</td>
</tr>
<tr>
<td></td>
<td>mm of H₂O</td>
</tr>
<tr>
<td>Vacuum</td>
<td>kg/cm²</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
</tr>
<tr>
<td>Level</td>
<td>%</td>
</tr>
<tr>
<td>Analysis</td>
<td>%</td>
</tr>
</tbody>
</table>
Conductivity : $\mu$S (micron Siemens)

Viscosity : mPa.s (cP)

2.7 Local control loops shall not be provided, unless it is specifically required as per P&ID.

2.8 Instrument Sizing

a) Contractor shall be responsible for sizing of all instrument items like control valves, pressure relief valves, desuperheaters, orifice plates, other flow elements etc.

b) The control valve and pressure relief valve sizes as indicated in the P&ID or in data sheets (whenever indicated) is tentative only and need to be resized by contractor after due verification of the process data. Whenever the sizes differ from those indicated in the tender document, the same should be brought to the purchaser's notice. Contractor, in such cases shall proceed only after approval from purchaser.

c) In case line sizes are required to be increased or reduced because of valve or flow element sizing, the same shall be taken care of by the contractor.

d) Sizing guidelines as indicated in the tender document shall be followed. In case no guidelines are provided, contractor may use national/international standards / standard practices for sizing.

2.9 Ranges for instruments shall be selected in general, such that in normal process operation the indication is between 40% to 60% of span for linear and 60% to 80% of span for square root inputs.

2.10 Ranges for process switches' shall be selected, in general, such that the set point falls preferably in the middle 30% of full adjustable range i.e. the set Point shall fall between 35% and 65% of adjustable range.

2.11 All controllers shall have facility for bumpless auto-manual and manual-auto transfer and set point adjustment. Flow, pressured level controller shall be provided with proportional plus integral action while temperature controller with proportional plus 'integral plus derivative' action.

2.12 Field mounted direct actuated flow and temperature switches shall not be used. Instead receiver/ switch/trip amplifier shall be used along with flow element/temperature element. Whenever specified in job specification, flow and temperature transmitters may be directly connected to control system to achieve switch action.

2.13 Intrinsically Safe System Requirements

Following points must be considered while designing an intrinsically safe system:

a) All intrinsic safety barriers shall be active isolating type only and shall have isolation between input output and power supply.

b) Barriers must be selected based on entity concept. Cable parameters shall also be considered while matching entity parameters.

c) The signal transfer accuracy of barrier shall be at least equal to or better than the transmitter selected.
d) Each instrument in the hazardous area and the intrinsic barrier shall be certified for intrinsic safety by a statutory authority.

e) Each input and output in a loop shall have separate barrier. No barrier shall be shared between two loops or input/outputs.

f) Any intrinsically safe loop requiring any device to be connected in the hazardous side permanently or temporarily, shall also be intrinsically safe.

g) Configuration tools whenever required for any intrinsically safe item which forms part of the intrinsically safe item shall also be certified intrinsically safe.

h) Universal barrier with programmable capability shall be used for temperature inputs i.e. for thermo couple/RTD inputs.

i) It is desirable to use one make of barrier for entire plant. The series' shall be of MTL / P&F.

2.14 Power Supplies and their Distribution

a) Following power supply voltage levels shall be used, unless otherwise specified:
   - For Instruments, Control Systems 110VAC ±10%(UPS)
   - Analyzers 50 Hz ± 3 Hz
   - Solenoid Valves, Relays, lamps 110 V DC ±10%
   - Input interrogation voltage 110 V DC ± 10%
   - Panel/cabinets lighting 240 V AC ± 10%

Any voltage level other than 110VAC UPS (including 24 V DC) if required for powering any subsystem, input interrogation, relays and lamps etc same shall be generated by the bidder using dual redundant power packs. (110 V AC to 24 V DC convertor).

b) All instruments; control systems (PLC and DCS) and analyser system shall be able to operate at the following power supply specification:
   - Voltage level : 110 V AC ± 10%
   - Frequency : 50 Hz ±3 Hz
   - Switch over time : 5 mili seconds

c) Power feeders if specifically indicated, shall be supplied to the bidder at only one location. All further distribution within the package shall be taken care of by the bidder.
d) Instrument power circuits shall be individually protected from fault with the help of fuses. Power supply to the individual instrument shall be disconnected with the help of Double Pole Single Throw (DPST) switch and protected with the help of fuses. Miniature circuit breakers (MCB's) may be selected in place of switch fuse unit in case protection is provided for overload protection.

2.14.1 110V AC UPS

2.14.1.1 Power from UPS shall be distributed to individual consumer with the switch -Fuse/Miniature Circuit Breaker (MCB) of appropriate ratings. Completely isolated feeders with isolating transformer shall be provided for DCS, free issue control room mounted panels/equipments, package items in the field etc.

2.14.1.2 20% feeder or minimum of one number of each feeder shall be provided as spare. UPS shall be sized accordingly.

2.14.1.3 The main isolator shall be DPST type to isolate AC line and neutral. Likewise individual distribution feeders to have isolators of DPST type to isolate line and neutral.

2.14.1.4 In order to obtain proper fuse coordination following point must be taken into consideration.

a) All the feeders for DCS shall feed to separate sets of bus bars (line and neutral).

b) All the sets of feeders shall be fully independent and shall not be joined together at any point.

2.14.1.5 Voltmeter and ammeter in each main power feeder entry point inside the power supply distribution board shall be provided.

2.14.1.6 Automatic sequential start-up facility for power supply in the AC distribution board shall be provided. For power supply distribution drawing, details shall be referred in job specification.

2.14.2 DC POWER DISTRIBUTION

2.14.2.1 Main isolators shall be DPST (double pole single throw) type to isolate both lines with HRC fuse on both lines. Likewise individual distribution feeders shall have isolation of DPST type and fuse on both DC lines.

2.14.2.2 Contractor shall provide 20% (minimum quantity at least one) spare power distribution outlet with isolators and fuses for each branch line for all types and quantities used for each category. The charger/rectifier and battery shall be sized to cater for 30% spare feeder as specified above.

2.14.2.3 DC power distribution shall be designed to avoid any common mode failure. Power supply distribution drawing shall be referred form job specifications for details.

2.14.3 230 V AC Non UPS Power Distribution

2.14.3.1 Main and individual distribution feeder shall be provided with switch-fuse assembly or MCB.

2.14.3.2 The contractor to note that 230V AC non-UPS shall be used for panel lighting level gauge illumination, analyzer shelter and cabinet lighting etc. Necessary distributions of the same for the items specified above and supply and laying of the power supply cables from the switchgear to the field shall be by the contractor.

2.15 Alarm Philosophy
a) Adequate alarms shall be provided to give audible and visual warning of any process and machine malfunction in the package.

b) All trips shall have a pre-trip warning alarm in addition to alarm at the trip condition.

c) All package alarms including pre-trip warning alarms’ and trip alarms (shutdown alarms) shall be annunciating on the local panel. First out alarm sequence as per F3A as per ISA shall be provided, whenever required.

d) All rotating equipments shall have the status indication provided on the local panel wherever applicable.

e) Wherever printer is provided, all alarms shall be printed as and when they appear, in the sequence of their occurrence.

f) Common pre-warning alarm and common trip alarm contacts for the sub packages shall be provided for remote annunciation. Additional alarm contacts shall be provided, when specified.

g) 'Fail-safe' type with normally closed alarm contacts shall be used.

2.16 All line or equipment mounted instruments like control 'valves, pressure relief valves, thermowells, orifice flanges, level instruments and analyzer instruments etc., installed on pipes and vessels under ffiR service shall be certified by 'ffiB. or their authorized representative.

2.17 Location of process connections shall be from the side or from the top of the process equipment but not from the bottom. This requirement is applicable to both pipes and vessels. The location of lower side connection when necessary, shall be high enough inside vessel to prevent plugging due to dirt or other suspended solids. In addition, the connections shall be short, vertical or horizontal and without any pockets.

Material of construction of instruments shall be as per the material selection guide lines, provided with this specification. And any specific requirement of material of construction by purchaser/purchaser's representative during detail engineering shall be complied by contractor without any time/cost implications. In any case vendor to ensure that the selected material is consistent with temperature, 'pressure, corrosion conditions and other process requirements.

In case where suitable material of construction is not feasible/possible, diaphragm seal shall be considered.

2.18 All, process switches shall be provided with sealed micro switch contacts rated’ for the specified application. Contacts shall be Single Pole Double Throw (S~on type unless otherwise specified. Contacts used in intrinsically safe applications shall be gold plated.

2.19 Instrument Connections

The connections of instruments installed on vessels, tanks, standpipes and piping shall be as per following Standards, unless otherwise specified in licensor's package.

a) 1071-7-52-0001 - Instrument Connections on Vessels and tanks

b) 1071-7-52-0002 - Instrument connection on Piping.

c) For clad vessel minimum connection size shall be 3"

2.19.2 Pneumatic instrument connections for signal and air supply shall be 1/4" NPT(F).
2.19.3 Electrical cable entry connection shall be 1/2” NPT (F). Suitable cable gland shall be used.

2.19.4 End connections shall meet the following, unless, otherwise specified:
   a) Threaded end connection shall be NPT as per ANSI/ASME B1.20.1.
   b) Flanged end connection shall be as per ANSI/ASME B16.5.
   c) Flange face finish shall be per paragraphs 6.4.4.1, 6.4.4.2 and 6.4.4.3 of ANSI/ASME B 16.5. The face finish wherever specified in data sheets shall have serration as follows:
      
      | Serration as follows | 250 to 500 AARH  |
      | 125 AARH             | 125 to 200 AARH  |
      | 63 AARH              | 32 to 63 AARH    |
   d) Grooves of ring type joint flanges shall be octagonal as per ANSI/ASME B 16.20

2.20 Air supply for the instruments at pressure specified elsewhere shall be made available to the contractor at the battery limit of the unit wherever specified in the job specification. Contractor shall be responsible for further distribution within the unit.

2.21 Interface with Main Control Room

2.21.1 Instrument junction boxes shall be provided as an interface with control rooms. Marshalling details for tubing and cabling shall be shown with corresponding junction box termination number allocated against appropriate instrument tag number. A separate drawing shall be furnished for interface wiring and tubing showing all instrument interface details between purchaser-vendor, wherever applicable. In general, the philosophy outlined in para 2.21.2.3 shall be followed.

2.21.2 Signal Interface Philosophy

2.21.2.1 Direct signals from field to control room
   a) All signals from "field to main control room/Satellite Rack Room (SRR) shall be terminated in the junction boxes located at appropriate locations in the field. Separate junction boxes shall be used for the following type of signals:
      - Intrinsically Safe Analog Inputs/Outputs (4-20 mA)
      - Non Intrinsically Safe Analog Inputs/Outputs (4-20 mA)
      - Intrinsically Safe Thermocouple Inputs
      - Intrinsically Safe RTD Inputs
      - Intrinsically Safe contact Inputs
      - Non Intrinsically Safe contact Inputs.
      - Non Intrinsically Safe contact Outputs.
b) An pulsed signals or serial signals shall be routed directly to control room(s) without tile
Use of intermediate junction boxes, in general. In case, where single cable length is a problem, intermediate junction boxes can be used, however in all such case, same junction box shall not share signals from two or more device.

  c) Whenever multidrop serial communication is adopted, intermediate junction boxes may be used for multidroping purpose only.

2.21.2.2 Signals from contractor's scope to purchaser

  a) Whenever signals are required to be routed for purchaser's use, contractor shall use separate dedicated junction box or terminal strip (in case of control panel/system cabinet) for each type of signal i.e for 4-20 mA 1 alarm / contacts/ temperature element etc.

  b) In case of serial signals, contractor shall provide a separate dedicated port for purchaser's use.

2.21.3 Intrinsically Safe barriers wherever required shall be provided by contractor as part of the control system to which these input / outputs are connected. Generally locating barriers in the local panels shall be avoided. If provided, the arrangement shall be made for proper earthing in the local panel.

2.22 Instrument Cables

Multicables between junction boxes and main control room (MCR) / or satellite room or any other control room shall be as per following philosophy:

  a) Signals (4-20 mA or switch 'contact): 6/12 pair r individually and over all shielded (screened) and armoured, twisted, 0.5 mm² conductor.

  b) Thermocouple: 6/12 pair thermocouple extension cable'(20 AWG)

  c) RID: 8 Triad 1.5 mm² conductor.

  d) Solenoid valves (110 V DC): 6/12 Pair shielded, armoured, , 1.5 mm- conductor.

Higher conductor size shall be selected to limit the voltage drop within the specified limit.

2.22.2 The colour of outer sheath, inner sheath and individual COre for each type of cable shall be as mentioned below:

<table>
<thead>
<tr>
<th>Type of cable</th>
<th>Signal type</th>
<th>Outer sheath</th>
<th>Conductor</th>
<th>Insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) signal</td>
<td>IS</td>
<td>blue</td>
<td>blue *</td>
<td>Black *</td>
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<tr>
<td></td>
<td>Non IS</td>
<td>black</td>
<td>blue *</td>
<td>Black *</td>
</tr>
<tr>
<td>b) control/power</td>
<td>black</td>
<td>red</td>
<td>Black</td>
<td></td>
</tr>
<tr>
<td>c) alarm</td>
<td>IS, Non IS</td>
<td>black</td>
<td>white</td>
<td>Black</td>
</tr>
<tr>
<td>d) extension</td>
<td>IS, cable</td>
<td>As per IEC 60584-3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Triad cable shall have blue, black and brown colour

2.23 Junction Boxes

2.23.1 Junction boxes shall be used for interconnection in the field wherever necessary as per para 2.21.2. Analog signals (4 - 20 mA), switch contacts, temperature elements, LEL detectors, intrinsically
safe, non intrinsically safe and low voltage contact signals shall be segregated in the separate junction boxes. Separate' junction box shall also be used for signals and 'contacts connected to PLC, DCS or and other system.

2.23.2 The junction box shall be suitable for the type of signal and type of multicore cables used as indicated in para 2.21. 7. Unless otherwise specified, contractor must use the following

Type of junction boxes:

- For all intrinsically safe signals: Weatherproof junction boxes
- For all input/output connected: Explosion proof/flameproof to explosion proof/flameproof: junction boxes

instruments

2.23.3 The junction boxes shall have cable entries suitable for the multi -d single cables used. 20 %’addition cable entries must be provided. Unused entries shall be plugged. The junction boxes shall have terminals suitable for the cable wire size and shall preferably be of Phoenix or equivalent make.

All junction boxes used in intrinsically safe service shall be sky blue in colour while those in non-intrinsically safe service shall be painted gray.

2.23.4 The multi cable entry for 6 pair Junction Box (JB) shall be 1’ NPTF and for 12 pair / 8 triad junction box, it shall be 1 1/2I NPTF. Each junction box shall be provided with 2 multicable entries with one plugged with weatherproof, flameproof plug as required. Multicable entries shall be from the bottom whereas 1 pair/triad from the side.

2.24 Philosophy of Junction Box and Cabling

i) Overhead ducts shall be used for routing multicables in the unit and upto control room unless specified-otherwise. This main duct shall be routed over the pipe rack with suitable accessible location.

ii) Contractor shall provide continuous channel for support of the" overhead duct and the same shall be suitable for a load considering 100% filling of the duct by cables." However as a good engineering practice duct shall be sized considering "60% occupancy of the duct by cables. For ladder and angle trays contractor shall" provide support at a minimum interval of 1.5 m.

iii) In duct 4-20 mA signal cables, alarm" cables, thermocouple "cables and RID cables can run together in one compartment. The control and powerful (110 V DC) shall run in other compartment. The middle compartment shall be kept vacant. It shall be used for plant communication cable where specified.

2.25 Multi Cable Transit

2.25.1 The cable entry into the control room, satellite rack rooms, local control rooms, analyser rooms/shelters shall be through Multi Cable Transit Blocks (MCT). The MCT’s shall be sized, supplied and installed at site by contractor. The required cutout sizes and act frames sizes shall be calculated and shall be coordinated with control room contractor.

2.25.2 The MCT frames shall be of Standard RGB type of Brattberg or Roxtec or equivalent and of Steel construction. The maximum height of frame shall not exceed 600 mm, unless otherwise specified. The MCT frames provided shall be suitable to withstand blast intensity for which: blast proof control room
has been designed. The MCT shall be supplied complete with insert blocks, spare blocks, stay plates, end packing etc.

2.25.3 Contractor shall size and provide MCT considering 50% spares for each cable size / cable OD. Intrinsically safe cables, low power cables, non-intrinsically safe cables and power cables for instruments (110 V AC or above) shall be suitably separated from the other / cables within the MCT frame. Separate MCT frame shall be considered for electrical cables. The MCT shall be installed as per the recommended practice of supplier. No spare space shall be left uncovered in the frame and shall be filled with dummy block of suitable size. In addition to the above, contractor shall also supply 30% spare insert blocks in each cable size/cable on as loose supply.

2.26 Repeat Signals from Sub-Package Local Panel

   a) Generally separate ills shall be used for interfacing signals from sub-package to control room.

   b) Where signals as indicated in clause above is less in number and do not justify separate junction boxes, all such signals may be routed via local control panel if supplied by contractor.

   c) All such signals shall be terminated on separate terminal strips in the local control panel. The terminal strips shall be segregated as per para 2.21.2.1(a). The non-intrinsically safe signals shall be provided in certified flame proof junction boxes in local panels.

   d) Intrinsically safe barriers for all intrinsically safe signals, wherever required, shall be provided.

2.27 Requirement for instrument in steam service

2.27.1 All in-line instruments such as control valve, thermowell, orifice flanges, pressure relief valves, all types of level instruments and any other in the instrument shall be provided with IBR form II C certificate.

2.27.2 All pressure relieving devices shall be designed in accordance with ASME code for 'Boilers and Pressure Vessels', API-52! and Indian Boiler Regulations. In case of valves as 'per IBR, the same shall be to regulation no. 294 with 5% over pressure and regulation no. 295 with 5% blow down and shall be provided with the following certificates.

   i) IBR form-me certificate of manufacture and test of boiler mountings and fittings.

   ii) Type test certificate from IBR authority as per regulation no. 293 and Appendix-L of IBR for the valve series supplied.

   iii) Radiography of all castings shall be as per piping material specification.

2.27.3 The discharge capacity of pressure relief valves as in (a) above shall be calculated as per IBR regulation no. 293 a, b and c.

2.27.4 Detailed requirement of Pressure Relief Valve is given else where in this specification.

2.27.5 Installation item like syphon, condensate chambers, impulse pipe and pipe fittings connected with IBR lines shall have IBR form II C certification.

2.28 All instruments shall have internal terminal block for cable termination. Flying leads are not acceptable.
2.29 Diaphragm seal instruments with capillary shall be used for congealing, and various services, where plugging of element may occur or where suitable material is not available. in highly corrosive services. In these cases the flange material shall be in accordance with piping classes. Spacer ring shall be provided along with vent and drawing. Capillary shall be minimum AISI 316 S S with AISI 304 S 5 armouring. Seal fluid shall be suitable for the temperature.

2.30 Temperature extension of suitable length shall be provided in the impulse line of the instrument installation where process fluid temperature is higher than the maximum Withstanding temperature of the instrument.

2.31 The in-line instruments on fully jacketed lines shall also be jacketed.

2.32 Interlock and 'Shutdown System shall be an independent. system with its own dedicated primary element except for flow. In which case common flow element with separate transmitter shall be used. However separate element with trip amplifier shall be used for temperature. In no case the initiating contacts shall be derived from indicators, controllers, recorders, scanners, alarm annunciator or any such instrument.

2.33 The interlock & shutdown system shall be designed fail safe and shall meet the following requirements, as a minimum :

   a) All initiating contacts shall be close under normal conditions and shall open under abnormal conditions.

   b) All relays and solenoid valves shall be energised under normal conditions and shall de- energise under abnormal conditions.

   c) Emergency shut down switch contacts shall be wired in series with the final actuating device to ensure positive shutdown.

   d) If desired, because of operational or maintenance requirements, adequate trip bypass facilities are to be provided with warning lights to indicate that the trip has been bypassed. Trip bypass alarms shall be provided in local on local panel as well as in remote location. All such by-pass switches' shall be key-operated type.

2.34 The interlock & shutdown system shall be designed using electromagnetic relays unless specified otherwise and shall be located locally or remotely as per the operational requirements. The system shall meet the following requirements as a minimum:

   a) The electromagnetic relays shall be low power continuously rated type and shall have LED for status indication.

   b) The relays shall be plug-in-type and their plug-in-bases shall have screwed terminals for interconnection, Lug type soldered’ connection shall not be acceptable.

   c) Each relay shall have three numbers of 'NO'(normally open) and three number of INC (normally closed) contacts, as a minimum-each suitable .to drive the connected load. Out of these, one 'NO' and one 'NC' contacts shall not be used.

   d) Each shutdown/interlock logic shall be individually protected using separate switch- fuse unit and shall have a lamp for indicating power healthy status.

2.35 Each shutdown circuit and solenoid valve shall be provided with a switch-fuse unit separately.
Programmable Logic Controller (P–C) whenever used for interlock and shutdown, shall be located in environmentally controlled remote control room or satellite rack room. This shall meet the following minimum requirements:

a) PLC shall have dual redundant or triple redundant as specified in job specification. Redundancy for Oil/Power Supply/Communication network shall be provided as per selected configuration.

b) The software shall include the operating system and application program. The application program shall include software for performing functions like interlock and shutdown logic, programming/program modification, documentation etc. Two copies of application program and two set of licensed system software shall be supplied.

c) The system shall be supplied with programming tools and related accessories,

d) No two shutdown circuits shall be shared by same I/O module, unless specified otherwise.

e) For detailed DCS / PLC specifications refer standard specification for 1071-6-52-0055 for DCS / PLC.

f) TUV approval, wherever required shall be specified in the job specification.

2.36 All electronics/microprocessor based instruments/systems shall be provided with Y2K compliance certificate as per requirement of BSI DISC PD2000.

2.37 Contractor shall provide four sets of back up configuration in floppy media. The drawings should be in AutoCAD (latest version) and all documents in electronic media in addition to hard copy/ reproducibles as a part of project requirement.

2.38 Unit rate of all items/modules and hardware shall be specified by contractor for any future addition/deletion for system related items. This price shall include all engineering charges, installation, software charges etc. related to the effected addition/deletion.

All necessary furniture required for mounting consoles, printers, CRT's, video copier etc. shall be provided by the contractor.

3. SPARES PHILOSOPHY

3.1 Mandatory Spares

Mandatory spares for instrumentation and control system shall be provided as below unless otherwise specified in the job specification:

a) 5% spare instruments or minimum one of each range, type and material of construction (except for control valves, pressure relief valves, displacer type instruments, level gauges, flow meters, analysers and special instruments)

b) 5% or minimum one module for all control systems (DCS/PLC/PG's/ESD etc.) 2-years operational spares

Unless otherwise specified in the job specifications, all spares for 2 years of operation like gaskets, O-rings, diaphragms etc. as required for all instruments for two years of trouble free operation shall be provided.
3.3 Commissioning spares

Any kind of spares required for start-up & commissioning shall be provided.

3.4 Consumable Spares

Consumable spares for a minimum of one year duration after acceptance and shall include chart paper, printer paper, ink, cartridges, floppies etc required for recorders, printers and hard copier units, unless otherwise specified elsewhere.

4. GENERAL REQUIREMENT OF INSTRUMENTS

4.1 Instrument Concept

Major instrumentation shall be electronic type with final control elements as pneumatic.

4.1 Electronic Instruments

a) All electronic instruments requiring separate power supply, shall generally operate on 110 V 50 Hz. Instruments operating at 24 V DC shall also be acceptable.

b) Electronic transmitters shall generally be two wire type. These shall have transmission/output signal of 4-20 mA DC and shall be capable of delivering rated current into external load of at least 600Ω when powered with 24 V DC nominal voltage.

c) Smart transmitter when selected, shall be used in analog output mode, Digital integration shall be avoided unless specified otherwise.

d) All receiver instruments shall be microprocessor based and shall operate on voltage input of 0.25 to 1.25 V, 1 to 5 V, or 0 to 10 V DC, in general.

e) The design of electronic instruments shall be in compliance with the electromagnetic compatibility requirements as per IEG - 801.

4.1.3 Pneumatic instruments whenever used shall operate on air supply of 1.4 kg/cm²g and shall have transmission and output signal of 0.2 to 1.0 kg/cm²g.

4.1.4 Instrument air quality shall be as per ISA-S7.3 and free from corrosive, hazardous and toxic contaminants.

4.2 Panel Board Instruments:

4.2.1 Panel board instruments shall generally be multibin subminiature 6\" x 3\", except recorders, which shall preferably be 6\" x 6\". Instruments like microprocessor based recorders, temperature scanners etc., shall be as per manufacturer standards.

4.2.2 Panel board instruments shall have the following graduations, in general:

- Differential pressure flow meters: 0 to 10 square root
- Variable area flow meters: 1 to 10 linear
- Pressure: Direct Reading
Level : 0 to 100 Linear

Temperature : Direct Reading

Multiplying factors for flow scales shall be specified on manufacturer’s name plate. Recorder charts shall be dual graduated, in general, in 0 to 10 square root and in 0 to 10 linear.

4.2.3 Subminiature recorders shall have 100. nun s trip chart with chart speed of 25 mm/h. Microprocessor based recorders shall have strip chart 250mm approx, and chart speed of 50 mm/h with a provision to change speed at site.

4.2.4 Annunciators, in general, shall be solid state type with plug in modules, in a cabinet with back lighted engraved windows and integral power supply. Alarm logic module shall be single channel type. In case multi-input alarm module are selected, only one channel shall be used.

Intrinsically safe annunciator circuit, when used, shall have power supply unit in a safe area. Annunciator alarm sequence shall be as per F3A of ISA.

The design of the alarm annunciator system shall be such that transient alarms of less than 330 milliseconds duration shall be automatically rejected.

4.3 Control Panel

4.3.1 All control panels shall be s supplied in pre-tubed/pre-wired conditioned and s hall be completely tested at manufacturer's works prior to despatch.

4.3.2 Control panels shall be free standing type and fabricated preferably from 3 mm thick cold rolled steel-sheet, If the same is not available, 4 mm thick hot rolled steel sheet shall be used. Angle iron frame work shall use a minimum section of 50 x SOx 4 rom angle. The finish shall include sand blasting, grinding, chemical cleaning, surface finishing' by suitable filler and two coats of high grade lacquer with wet sanding between coats. Two coats of paint in panel colour shall be given for non-glossy high stain finish. Panel face final colour can be any of the following shades as per to 1S-5

Opaline green : ISC No.- 275
Light Admiralty Grey : ISC No.- 697
Sky blue : ISC No.- 101

Panel rear surface, frame work and mounting plates shall have a finish colour of pale cream to IS-5 ISC No.- 352 or Beige to 15-5 ISC No.-388. A final coat of paint shall be given at site. Equivalent colour shade according to BS/RAL are also acceptable.

4.3.3 Control panel shall be open back with each section of typically 2100 mm high, 1200 mm wide and 800 mm deep, when mounted inside the control room o~ 100 nun channel base covering wall to wall, else these shall be totally enclosed cubicule type. The panel width may be increased if necessary.

4.3.4 Enclosed cubicule panels shall have removable hinged doors, generally at the Side or back for easy maintenance and accessibility of the instruments. Doors shall 'be' double leaved type with handle and shall be provided with lock and key. Adequate illumination shall be provided inside the panel. All light fittings shall be suitable for 230 V, 50 Hz Ac.

4.3.5 No process fluid of any kind, except instrument air shall enter the control panel. Also power supply greater than 230 V shall not enter the local panel.
4.3.6 All cable entries to the local panel shall be from panel bottom only using cable glands of adequate size. Cable gland plate thickness shall be a minimum of 3 mm cold rolled cold annealed (CRCA) as a minimum. All unused cable entries must be plugged.

4.3.7 Space heater shall be provided where condensation is expected.

4.3.8 The design of control panel shall incorporate provision for expansion by installing adequate spare capacity. Each panel shall be designed to accommodate the following additional equipment, as a minimum:
   a) 20% of panel front/inside mounted instruments including lamps, push buttons, switches, relays etc.
   b) 20% additional power feeders each provided with switch fuse assembly.
   c) 20% additional spare windows in alarm annunciators.
   d) 20% spare cable entry points.

4.3.9 Panel layout shall be designed considering ease of operation. No push button or hand switch shall be located below 600 rom. Instrument Mounting heights,~ general, shall be as follows:-
   a) Miniature and subminiature instruments (3 rows) Bottom row 110mm
      Top row 1600mm
   b) Annunciators - 1950mm
   c) Electric push buttons/
      Switches, lamps etc.

4.3.10 The internal panel layout shall be designed considering proper approach for instruments, terminals and other accessories for maintenance, easy removal-and online calibration. No instrument, terminals, power distribution box etc shall be mounted on- the panel side plates inside the panel.

4.3.11 All lamps, status as well as alarm, shall be provided with lamp test facility. One single lamp test push button shall be used for each panel.

4.3.12 Colour Scheme
   a) Status Lamps
      On/Open/Permissive : Green
      Off/Close/Emergency : Red
   b) Alarms
      Normal/Pre-trip alarms : White
      Shutdown alarms : Red
   c) Push/Pull buttons
4.3.13 Panel Piping and Tubing

4.3.13.1 The instrument air header shall be adequately sized with brass packless isolation valves and shall be complete with suitable dual filter-cum-air reducing station.

4.3.13.2 Panel tubing from the bulk head to the panel instruments and instrument air supply to the panel instruments shall be of 6 mm x 1 mm. polyethylene tubing.

4.3.13.3 The tubing shall be laid in plastic slotted ducts. Panel air header and tube fittings shall be of brass, suitably protected against corrosion.

4.3.13.4 Shut off valves shall be installed in all branch lines taking off the transmission and output signal. Each tube shall be identified at both the terminating ends.

4.3.14 Panel Writing

4.3.14.1 Open terminals shall generally be avoided. Terminal strips shall be of Phoenix/Klippon/Elmex' or equivalent type and shall preferably be mounted in an enclosure. Fused terminal may be used wherever necessary.

4.3.14.2 A Minimum of 1 mms multi stranded PVC insulated copper conductor shall be used in general. All wiring shall be laid in the PVC troughs. No trough shall be more than 70% full.

4.3.14.3 Wires carrying measurement signals associated with thermocouples, resistance thermometers, pH instruments and other low level signals shall be routed in separate troughs/wire ways and not along with power cables. Power wiring and control wiring shall be separated by not less than 150 mm. The crossing, if unavoidable, shall be at right angles as possible.

4.3.14.4 Extension cables/wires shall be used for all thermocouple' inputs. These wires shall be routed in separate troughs/wire ways.

4.3.14.5 All intrinsically safe wires shall be routed in separate wire ways from non-intrinsically safe and power wiring. Intrinsically safe wiring and terminals shall be light blue in colour and shall be separated from non-intrinsically safe terminals at least by 50 mm.

1.3.14.6 All incoming power feeders shall be terminated on separate terminals suitable for the incoming feeder size. These shall be located at the bottom of the panel and shall be suitably covered for protection against accidental shorting and for human safety.

4.3.14.7 Following design philosophy shall be followed, while deciding the internal layout of panels, as a minimum:

   a) Distance between terminal strip and side of the panel upto 50 terminals 100mm (min.) + trough width
### STANDARD SPECIFICATION FOR INSTRUMENTATION WORK

<table>
<thead>
<tr>
<th>STD-0099</th>
<th>0</th>
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<tr>
<td>Rev</td>
<td></td>
</tr>
<tr>
<td>SHEET 28 OF 79</td>
<td></td>
</tr>
</tbody>
</table>

|   |   |
| b) | Distance between two adjacent terminal strips |
|    | 100mm (min.) + trough width |
| c) | Distance between gland plate and bottom of the strip |
|    | 300mm (min.) |
| d) | Distance of terminal strip from instrument/trough/panel top |
|    | 100mm (min.) |

### 4.4 Local Control Panel

Local control panel for the package units shall be installed within the battery limit of the package considering operational and maintenance requirements and accessibility. In case of skid mounted packages, panel all be located away from the skid.

In case local control panel is housed outdoor i.e. not in a local control room, it shall be designed to meet IP-55 requirements. In addition, panel must be provided with a rain cum sun shade canopy/shed.

#### 4.4.2 Local control panel/panels shall be totally enclosed cubicles. Panel sizing shall be carried out

based on equipment being installed keeping in view the maintenance clearances and easiness. Although the panel dimensions shall be guided by the actual requirements typical dimensions of 2100 mm operational (height) x 1200 nun (width) x 1000 mm (depth) shall be kept in mind while finalising the panel size. In any case, vendor shall not proceed with panel manufacturing before getting prior approval from the purchaser.

#### 4.4.3 Local control panels located in the hazardous area shall be either purged type or flameproof Ex’d as specified in the job specification. In case pressurised panels are specified the same shall be purged and pressurised as per NFPA-496 requirements to render space within the panel non hazardous. For panels, located in me Zone 2 hazardous area type Z purging, shall be used with a purge fail alarm in main control room. In case, panels are located in Zone-1, the power shall be cut-off on pressurisation X purge requirement of NFPA-496. An alarm shall be provided on local panel and a contact shall be provided for remote annunciation, whenever the panel pressurisation falls below 2.5 m m of H2O A protective device to protect the panel from over pressure must be provided.

#### 4.4.4 Panel pressurisation with start-up panel purging scheme shall be fully automatic however it shall be started manually from a push button. Solenoid valves and differential pressure switch required for panel purging shall be flameproof, however other items like relays, switches/pushbuttons, timers etc. shall be located in a flameproof housing. Other items like valves, restriction orifice plates, dual filter regulators, pressure gauges, variable area flowmeters etc. required for pressurization, shall also be located in the non-pressurised section of the panel manufacturers suitable for the specified pressure-temperature conditions. The thermowell design shall ensure no air gap between the tip of the element and thermowell to minimise measurement lag.

### c) Contractor shall carry out the vibration analysis of all thermowells as per PTC codes where line velocity exceeds 6 m/s for liquids and 120 m/s for vapours/gases. In case the thermowell design fails vibration analysis, an alternate design may be used by the contractor. All such design along with calculations shall be submitted for purchaser's review.

### d) Immersion length of thermowells shall be selected as follows:
4.6.2 Temperature Gauges

   a) Local temperature gauges shall be liquid/vapour/gas filled type in general and shall be
       manufactured as per relevant SAMA Class. Bimetallic gauges shall be considered if required as per
       licensor package or specified in job specification. The temperature bulb shall be of SS 316 construction
       as a minimum.

   b) All local temperature gauges shall have 150 mm dial size with adjustable head. The
       bulb size shall be selected to suit the thermowell.

   c) All gauges shall be of heavy duty weatherproof construction.

   d) Temperature gauges shall have accuracy of ±1% URV (upper range value)

   e) Bimetallic temperature and direct filled system gauges shall be avoided where
       excessive vibrations are encountered such as compressors. Only filled type with capillary extension shall
       be used in such applications. Capillary tubing shall be minimum of SS304 with stainless steel flexible
       armouring, having PVC covering over armour.

   f) It shall be possible to adjust gauge stem length by using adjustable gland with union. All such
       fittings shall be suitable for 1/2" NPTF connection to suit thermowell.

4.6.3 Temperature Elements

   a) For remote temperature indication/recording/control/switch etc., thermocouples or
       resistance temperature detector (RTD) shall be used depending on the process requirements. Elements
       shall be spring loaded, mineral insulated and shall have SS 316 sheath as minimum.

   b) The design of thermocouple assemblies shall be as per Standard 1071-7-52-0036 i.e.,
       Thermocouple/RTD assembly with thermowell and shall allow online replacement of temperature
       element. The element head shall be screwed-in type and weatherproof to IF-56 as a minimum. For
       thermocouple assembly, the terminals shall be color coded as per element color code.

   c) Thermocouples shall be magnesium oxide (MgO) filled ungrounded type, unless
       specified otherwise, Thermocouple characteristics shall be as per IEC-584-2/IS7358. The type of
thermocouple shall be selected based on operating temperature conditions. Following guidelines shall be followed in general unless specified otherwise:

- Copper-Constantan (ISA-Type-T) : (-) 200 to 200°C
- Chromel-Constantan (ISA-Type-E) : 200 to 600°C
- Chromel-Alumel (ISA-Type-K) : 600 to 1200°C
- Platinum Rhodium-Platinum (ISA Type-S) : 1200 to 1600°C

d) Thermocouple wire size shall be 18 A WG for single and 20 A WG for double thermocouple for most of the applications, in general. However following guidelines shall be followed for selecting single thermocouple wire size as a minimum

<table>
<thead>
<tr>
<th>Type</th>
<th>8 AWG</th>
<th>14 AWG</th>
<th>18 AWG</th>
<th>24 AWG</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td></td>
<td>&gt;371°C</td>
<td>For all other</td>
<td>-</td>
</tr>
<tr>
<td>E</td>
<td>&gt;871°C</td>
<td>&gt;649°C</td>
<td>For all other</td>
<td>-</td>
</tr>
<tr>
<td>K</td>
<td>&gt;1260°C</td>
<td>&gt;1093°C</td>
<td>For all other</td>
<td>-</td>
</tr>
<tr>
<td>S</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>&lt;1482°C</td>
</tr>
</tbody>
</table>

e) The design of thermocouple assemblies shall be such that replacement on line is possible.

f) RTD (Resistance Temperature Detector) shall be platinum element 3 wire type with 100 Ω resistance at 0°C calibrated as per IEC 751/DIN 43760. RTD shall be used within a temperature range of -200 to 650°C.

g) RID shall generally be selected for applications requiring low temperature measurement with comparatively shorter temperature span requiring accuracies of the order of 0.25% or better.

h) Twin element sensors, if used, shall have two separate cable entries.

i) The special thermocouples such as reactor thermocouples, reactor / vessel skin thermocouples etc shall be designed by contractor based on specifications/details provided elsewhere in the contract document.

j) Heater tube skin thermocouple, where applicable, assembly shall meet the heater design requirements and shall be provided with expansion loops. The sheath material shall be selected based on temperature and sulphur content and shall be as per API recommendation.

4.6.4 Temperature Transmitter
a) Unless specified otherwise, temperature transmitters, shall be panel/rack mounted type only and shall be located in control room/satellite rack room. In case, field mounted transmitters are specified, separate field mounted transmitters shall be used, head mounted transmitters shall be avoided.

b) Temperature transmitters shall have a built-in linearising function to produce an output linear to temperature range.

c) Field mounted temperature transmitters shall be smart type with HART protocol having an accuracy of +/- 0.1 % of DRY. The other features of smart transmitters shall be the same as those covered under field transmitters.

d) Burn out protection must be provided with temperature transmitters and other temperature input devices. Upscale or down scale protection shall be decided based on the application to ensure fail safe operation.

4.7 Pressure Instruments

4.7.1 Pressure Gauges

a) Pressure gauge dial shall be white non rusting plastic with black figures. Pointers shall have external micrometer adjustment for gauge zero adjustment.

b) Pressure gauges shall be weatherproof with dial size of 150 mm and shall have features like screwed bezel externally adjustable zero, over range protection and blowout discs. Pressure gauge sensing element shall be of 88316 and movement of 88304, as a minimum. The design of pressure gauges shall confirm to 18-3624.

c) Pressure gauges shall have an accuracy of ±1% of URV as a minimum. Differential pressures gauges may have an accuracy of ±2% of URY.

d) Over range protector and pulsation dampener, whenever used, shall be of 88304, as a minimum. Pulsation dampeners shall be used for all pulsating services. These shall be floating pin type, externally mounted and externally adjustable.

e) All pressure gauges with maximum operating pressure exceeding 60 k g/cm² g and gauges in toxic service shall be solid front type.

f) Process connection shall normally be 1/2” NPTM bottom, except for diaphragm seal where 1½” flanged connection shall be used in general.

g) Cases shall normally be cast aluminium alloy or black phenol and weatherproof to IF-55 as per IEC-529/18-2147. Blow-out discs shall be provided for all gauges.

h) Ranges shall be so specified that the gauge normally operates in the middle third of the scale and shall conform to 18-3624 standard dials, wherever possible.

i) Diaphragm seal pressure gauge with capillary shall be used for congealing and viscous services, i.e. where plugging of the element may occur or where suitable material is not available in highly corrosive service. Direct mounted, filled type gauges or mechanical linked gauges (Schafer diaphragm type) shall be avoided for any mild to heavy vibrating service.

j) Receiver pressure gauges for local transmitter output indication shall have 100 mm dial with stainless steel element and 1/4” NPTM instrument connection,
4.7.2 Pressure Switches

a) Pressure switches shall have either diaphragm or bellow type of process element with SS316 material of construction as a minimum. Switch type shall be sealed micro type with 'contact rating suitable for specific application. Pressure switch design with Reed type switches shall not be selected.

b) Pressure switches shall be blind type with 1/2 NPTF process connection and shall be operative in full specified range, The switch differential shall be selected as per operating conditions, it shall be less than 60% of difference between set value and operating value.

c) Pressure switches shall have repeatability of ±0.5% of URV, as a minimum.

d) Receiver pressure switches shall have SS316 below as measuring element with 1/4" NPTF connection,

e) Over range protection and pulsation damper requirements and design shall be as per above clause.

f) Requirements, design and selection of diaphragm seal (chemical seal) for pressure switches shall be as per clause 4.7.1(f).

4.8 Level Instruments

4.8.1 Level gauges

a) All gauge glasses shall be steel armoured reflex or transparent type with body and cover material of forged carbon steel as a minimum and shall have tempered borosilicate glass with asbestos or other suitable gasket. Transparent type of gauges shall be provided with integral illuminators operating at 230 V 50 Hz supply and suitable for electrical area classification specified. All gauge glasses must have a rating equal to 'or more than the vessel design pressure and temperature.

b) Reflex type shall be used for clean and colourless liquids, for liquid level interface. For low temperature, low boiling point service, large chamber type will be used. Transparent type will be used on acid, caustic, dirty or viscous, coloured liquids and liquid interface. Transparent type with Mica or Kel-F shields shall be used for treated water, boiler and condensate services, and for corrosive liquids which will attack glass. Tubular gauge glasses shall not be used, in general. They may be used for non-hazardous services at ambient temperature and low pressures.

c) Large chamber gauges with frost shields shall be provided for cold services below 0°C. Heating jacket shall be provided for viscous liquids.

d) All gauges shall have top and bottom chamber connections, unless otherwise specified. In addition each gauge shall be provided with ball check valves and pipe union.

e) The visible range of level gauge shall be selected to cover the complete operating level as well as measuring range of the other level instruments provided for the same purpose. In general, the visible length of the level gauges shall be selected from the following:-

<table>
<thead>
<tr>
<th>Visible length, mm.</th>
<th>Centre to Centre Length, mm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>220</td>
<td>470</td>
</tr>
</tbody>
</table>
In any case, the maximum visibility length shall not exceed 1500 rom for a single gauge. Multiple gauges with overlapping range shall be used for such cases.

f) Gauge glass cocks shall be forged off-set type with an integral ball check and back seating stem. Primary isolation valves are normally required in addition to the gauge glass cocks, except on vented tanks containing harmless liquids. Where the process fluid tends to foul the cocks internals and create plugging or where leakage is a problem, gauge valve may be eliminated. On low temperature service, with liquids having very high vapour pressure at ambient temperature safety valve shall be provided at the vent connection of the gauge glass.

g) For level gauging in very viscous liquids, liquids with crystals, sour services and pressure above 600# toxic services, float operated magnetic gauges with 2” flanged end connections shall be used.

h) Bicolor type level gauges shall be used for steam drums.

4.8.2 Level Transmitter

a) External displacer type instruments with side-side connections and rotatable head shall normally be used for level measurement upto 1219 rom. Side-bottom connections are preferred where RJ flanges are required. Internal displacer type of level transmitters shall be avoided unless application necessitates its use.

b) All displacer type of level transmitters shall be of torque tube type with torque tube material of inconel, as a minimum.

c) In general, displacer type instruments shall be used with displacer lengths of 356 mm, 813 mm and 1219 rom. For interface level measurement; ‘displacer type instruments shall only be used.

d) Differential pressure transmitter shall be used for level measurement above 1219 mm, for services requiring purge or where liquid might boil in external portion.

e) Differential Pressure transmitters for use on corrosive or fouling service shall generally be diaphragm wafer with extended filled capillary type. Flush or extended diaphragm type differential pressure transmitter shall be considered for special applications only. Diaphragm material shall normally be stainless steel or any other special alloy.

f) Dip Tube type level transmitters may be used on corrosive, congealing, slurry services where suitable diaphragm seal type transmitter is difficult to obtain.

4.8.3 Level Switch

a) Level switches ‘shall generally be extended float type with flanged head. External displacer type level switches can be considered for lighter fluids where specific gravity is less than 0.5. Internal float / displacer type level switches shall only be used if external ball float / displacer type is not possible, like in viscous services and in underground tanks/vessels.

b) Multi-float / displacer level switches shall be avoided in process service,
c) Switch shall be sealed micro type with contact rating suitable for the specific application. Level switches with Reed switch shall not be used.

d) Level switch shall be furnished with SPDT contacts with adjustable differential, unless otherwise specified.

4.8.4 Tank Level Instruments

a) Mechanical float type gauges shall be used for atmosphere tanks where level measurement accuracy requirement is of the order of ±2% of span. Liquid seal chamber shall be used where tank contents are toxic or tank is blanketed.

b) Servo type gauges shall be used for level measurement of pressurized tanks/vessels/spheres requiring remote signal transmission and better level measurement accuracies. Level data transmission signal to remote control room shall be digital only. Servo type instruments shall have 6” process connection with 12” diameter still well.

c) The tank side indicator for both types of gauges shall have hoisting facility. All tank level gauges shall have side mounted indicator-counter type for mechanical float type and solid state digital for servo controlled level gauge.

d) The wetted material like float, displacer, tape, wire etc. shall generally be SS316.

e) The accessories for servo-controlled level gauge shall include calibration chamber and isolation ball valves for pressurised tanks. Isolation ban valve size shall be same as equipment nozzle size.

4.8.4.2 Whenever specified, averaging tank temperature element shall be provided. The temperature elements shall be RID. Number of temperature elements shall be as per ASTM D 1066. The temperature element shall be connected to corresponding gauge head and shall be intrinsically safe.

4.8.4.3 Radar type tank gauges shall be used for storage tanks handling viscous fluids or as specified in job specification.

4.8.4.4 All tank gauges shall be supplied with power ON-OFF switch mounted at grade level. Separate cable entries shall be provided for signal and power in the gauge head/tank side indicator/ON-OFF switch as applicable.

4.8.4.5 Other Special type of level instruments like radar, ultrasonic, hydrostatic, nucleonic, capacitance, conductivity type shall be used as necessitated by application requirements.

4.8.4.6 For high pressure steam drum application conductivity type (hydrostatic or equivalent) level instrument shall be preferred.

4.8.7 For solid level measurement, type of instrument shall be ultrasonic/radio frequency / electro-mechanical/capacitance/nucleonic. The actual type selection shall be carried out based on the provenness of the selected type for the similar type of application.

4.9 Flow Instruments

4.9.1 Orifice Plates

a) Flow measurement shall normally be carried out using thin square edged concentric orifice plate mounted between a pair of weld neck flanges of minimum 300 # ANSI rating for line size 2” and above. Flange taps shall be used for line sizes upto 14” while D-D/2 taps shall be used for line sizes 20” and above. For smaller line sizes, bypass type orifice meters with differential pressure transmitters may be used.
16" and above. For line sizes 1-112" and below for conical entrance orifices outer taps shall be used. Contractor to check fouling of tapping point with respect to welding of flange. In case of fouling, flange tap shall' only be used. The material of the orifice plates shall be normally SS316, as a minimum.

Quadrant edge or quarter circle orifice plates shall be used when lower Reynolds number does not permit the use of squared edge orifices as per codes. Conical entrance type of orifice plates shall preferably be used for very highly viscous liquids upto throat Reynolds number of 250. These shall be fabricated as per BS 1042 Part 1.

b) Vent and Drain holes shall be provided in orifice plates, wherever necessary.

c) Sizing of orifice plate shall be carried out in accordance with ISO-5167. Other sizing methods-like AGA Report No.3, BS-1042, Flow-measurement-Engineering Handbook' by R.W. Miller shall be used when specified.

d) Orifice plates shall be fabricated in accordance with standard 7-52-0041 'Orifice Plates and Flanges Dimensional Details'.

e) Differential range for orifice meter shall normally be 2500 m m of H2O dry calibration. Other preferred ranges are 500, 1250, 5000 and 10000 mm of H2O. However the selected value shall be less than the' allowable pressure drop mentioned in the process data sheet.

f) Upstream and downstream straight length shall be provided based on maximum d/D ratio of 0.75, in general. Where it is difficult to meet this requirement, the actual d/D ratio can be considered for reducing the straight length as permitted by the codes. The recommended practice shall be as per API-MPMS, Recommended Practices and AGA Report No.3. Flow straighteners should be considered, where straight runs are difficult to achieve otherwise.


g) Meter taps shall be horizontal for liquids, condensable vapours and steam. The taps shall be on top for gas, non-condensable vapour or liquids which boil at or based on the proveness of the 'selected type for the similar type of application below the maximum design ambient temperature at operating pressure, where piping clearances are a factor, taps may be located upto 45 0 above the horizontal centre line for condensable vapour, liquid and steam. The taps may be located upto 60° from vertical for gas and non condensable vapour. For 45° installation both the tappi ng point nipples are 4" long. For horizontal tappings on "liquid condensable vapour and steam service they shall be 4" long for one tapping and 6" long for the other.

h) Atleast one pair of tapping shall be provided for' each orifice flange. Where more than one transmitters are used, separate pair of tappings shall be provided for each orifice flange for each instrument for installation of each instrument separately.

4.9.2 Variable area flow meters shall be as per ISA-RP 16.1,16.2,16.3,16.4,16.5 and 16.6 shall be used for viscous or corrosive services or where rangeability in flow precludes the use of an orifice. Metal tube variable area flow meters shall be used for all process fluids. External devices for indicating or transmitting shall be magnetically coupled to the float or extension.

Glass tube variable area flow meters shall be used for low' pressure utility services for local indication and where line size is 1-112" or less. Glass tube variable area flow meters shall not be used if outlet line is connected to a line or vessel containing hazardous or toxic fluid unless a check valve is installed at the downstream side of variable ,area flow meters.

4.9.3 Turbine and positive displacement meters or mass flow meters shall be used for accurate flow integration for custody transfer etc. Whenever PD meter is selected, these shall be double casing type with inner casing of SS 316 as a minimum.
Whenever turbine meter is selected, it shall have SS 316 turbine with tungsten carbide bearings.

Pulser and the transmitter selected shall be compatible and should have a proven combination reference.

4.9.4 For flow measurement in lines less than 2", integral flow transmitters shall be selected. The integral flow assembly shall be supplied as an integral assembly consisting of upstream and downstream straight pipes, integral orifice of SS 316 (as a minimum) and transmitter installed along with manifold. Material of construction of cl.1 elements except for end flanges which shall be as per piping specifications, upstream and downstream pipes shall be honed from inside to achieve smooth surface.

Integral orifice meters, when used, shall be installed with block and bypass valves. Orifice meters with metering runs may also be used for lines less than 2"

4.9.5 Magnetic type flow meters shall be used for electrically conductive slurry or corrosive services and shall be installed with line size bypass, with block and clean' out valves, at the lowest point in piping to ensure that meter run is always liquid requirement. Grounding range shall be used whenever required.

4.9.6 Target meters shall be considered for highly viscous hydrocarbon streams such as asphalt, tar, polymers etc.

4.9.7 Vortex meter shall be considered where high rangeability is the prime requirement. Ultrasonic flow measurement shall be considered where non-intrusive flow measuring is required.

4.9.8 Averaging pitot tube shall be considered for low pressure loss, high velocity' steam, large diameter lines and air ducts. This shall be installed on 1-112" size nozzle for small lines and 3" for large lines or lines with high velocity. The average pitot tube shall be of SS 316 material as a minimum, shall be provided with end support, whenever required. Retraction arrangement with ball valves shall be provided for each average pitot tube installation.

4.9.9 Differential Pressure type flow transmitter shall meet all the requirements specified for field transmitters in this specification.

4.10 Field Transmitters

4.10.1 Field transmitters for flow, pressure, differential pressure and level applications shall be yoke mounted smart type unless specified otherwise. These transmitters shall be certified intrinsically safe, in general, with 2 wire system having 4 - 20 mA DC output with superimposed digital signal having simultaneous analog and digital communication. Communication protocol shall be HART only.

4.10.2 Transmitters shall be provided with external zero adjustment and shall have integral vent/ drain.

4.10.3 All transmitters shall be provided with integral intrinsically safe output meter. Intrinsically safe remote output meter shall only be provided, if specified in the P&IDs or in the job specifications. All output meters shall provide digital LCD display.

4.10.4 The transmitter shall be microprocessor based and it shall incorporate a non-volatile memory which shall store complete configuration data of transmitter. All necessary signal conversions, including conversion to produce output with the required protocol shall be carried out in the transmitter electronics.
4.10.5 Transmitter shall also run complete diagnostic routine. In the event of detection of failure, the output shall be driven to predefined value.

4.10.6 Temperature sensors shall be provided to compensate for process temperature and ambient temperature variations.

4.10.7 The transmitter shall be able to assure an accuracy of ±0.1% of span for a rangeability of 1:10, unless otherwise specified in the job specification. The accuracy shall include the combined effect of linearity, hysteresis and repeatability.

4.10.8 The response time of smart transmitters shall commensurate with process. It shall be equal or better than the half of the scan time of control loop specified elsewhere in the bid package.

4.10.9 HART protocol of latest version shall be used and shall be suitable for HART maintenance system with corner stone software or equivalent with the following features as minimum:

   a) It shall allow multi masters (two for example, primary and secondary) for configuration, calibration, diagnosis and maintenance. The primary could be control system or host computer and the secondary, could be the hand held communicator or a maintenance computer.

   b) It shall be capable of implementing universal commands. It must be possible to communicate all the commands of HART maintenance system to field transmitters and smart transmitters shall be selected accordingly.

4.10.10 Unless recommended otherwise by compressor manufacturer, field transmitters used in anti-surge control loop shall be non-smart and flameproof type. The flameproof transmitters shall have their calibration adjustment from outside without any, need to remove the cover.

4.10.11 Retrofit type of smart transmitters are not acceptable.

4.10.12 Diaphragm seal element with capillary shall be used for congealing, corrosive and highly viscous services.

4.10.13 Field communicator

   It shall be possible to perform routine configuration, calibration display process variable, diagnostics etc. from a hand held portable calibrator which can be connected at any location in the transmitter loop. It shall be possible to perform all the above functions on line. The loop function shall remain unaffected while communication is going on between transmitter and the field communicator. No output interruption should occur.

   Field communicator shall meet the following requirements.

   a) They shall be battery powered with replaceable and rechargeable batteries. Recharger power supply shall be 230 V AC ± 10 %, 50 Hz ± 3 Hz.

   b) It shall be possible to connect the communicator at any of the following places for purpose of digital communication:

      i) Marshalling cabinet serving the transmitter, 'in safe area, control room.'

      ii) Junction box serving the transmitter,' in hazardous area, field.

      iii) Directly at the transmitter, in hazardous area, field.
Plug in type connections shall be provided with field communicator. Necessary interconnection cable and any other accessories required for connection shall be supplied by vendor.

c) Offered communicator shall be dustproof, certified intrinsically safe and suitable for outdoor location. Carrying case shall be supplied with each communicator.

4.11 Control Valves

4.11.1 Control valves shall normally be globe type, single seated or double seated. Other type of valve like butterfly, ball, rotary plug, angle or 3 way etc., shall be 'selected as per service requirements.

4.11.2 Control valve sizing shall be carried out as per ISA S75-01. In general, control valves shall be sized so that the valve opening is as noted below:

- At max. flow: less than 90% open
- At normal flow about: 75% open
- At minimum flow more than: 20% open.

4.11.3 Unless specified otherwise flanged control valves shall be used. Body material, body rating and flange rating, shall be as per piping specifications, as a minimum.

4.11.4 Minimum control valve body size shall be 1" in general. Reduced trims can also be considered. Body size shall be limited to 1", 1-1/2", 2", 3", 4", 6", 8", 10", 12" and 14". Higher sizes may be used wherever necessary.

4.11.5 Trim characteristics shall be equal percentage type unless required otherwise because of process application. Control valve plugs shall be top and bottom guided for double seated valves and heavy top guided for single seated valves. Cage guided valves shall be selected for control valve size of 2" and above, in general.

4.11.6 Anti-cavitations trim shall be selected wherever cavitations is expected in the valve.

4.11.7 Noise from control valve during operation shall be limited to OSHA specified level or better. The maximum allowable noise is 85 dBA SPL (Sound Pressure Level) at 1 meter distance from the valve body. Source treatment for noise shall be preferred by using special trims like anti-noise trims, in case noise exceeds the allowable level. Path treatment may be adopted over and above source treatment, if necessary.

4.11.8 Valve seat leakage shall be as per ANSI/FCI 70.2 and shall be elected with due consideration to meet the requirement. For shutdown valves leakage class VI shall be considered.

4.11.9 Flanged bolted type gland packing boxes shall be used. Packing shall normally be PTFE on liquid and gas service upto 200°C. PTFE impregnated asbestos shall be used upto 260°C. Graphited asbestos with lubricator; shall be used on steam service and temperature above 260°C. Alternate suitable material is also acceptable.

4.11.10 Bellows seal shall be used where it is required to isolate the packing from the process fluid or where no leakage to phosphate can be tolerated, toxic, explosive and precious fluids.

11 4.11.11 Material used for trim shall be minimum SS316, with guide bushing of hardened stainless steel like 440C, 17-4 PH, upto a pressure drop of 10 kg/cm². For higher drops or erosive and slurry
services and in general for all steam services, flashing services, hard-surfacing of plug seat rings and seating area of inner valve with satellite shall be used. Special cases may require 17-4 PH seat ring and 440 C solid plugs or other materials like Hastelloy, Durimet, Monel etc.

For temperature above 300°C satellite facing shall be used for guide posts. Guide bushing shall always be harder by a minimum of 125 Brinnel than the guide post.

4.11.12 Contractor shall carry out cavitation and flashing checks for valves ill liquid service and select: the valve body and trim accordingly. Whenever the data provided is not adequate to carry out such checks, it shall be contractor's responsibility to evolve such a data and as certain the correctness of the valve sizing/selection.

4.11.13 Unless otherwise specified in P&ID, block and bypass' valves shall be installed for all control valves up to and including 2” size except for butterfly valves, 3 way valves and control valves in slurry and freezing service. Hand wheel shall be provided for all other sizes and services, No by-pass valve or hand wheel shall be used for shutdown valves.

4.11.14 Valve actuator shall be pneumatic spring opposed diaphragm type, in general. Piston type actuators may be used for very high shut off pressure requirements. Additional equipment necessary to meet fail safe condition shall also be included in case double acting piston type actuator is selected. Wherever double acting piston cylinder actuators are used, it shall be provided with complete accessories like volume tank, safety valve, non return valve and pressure gauges etc. The volume tank shall be designed for minimum of 2 full stroke operation of control valves in addition to backup for control valve operation for a preset time as given in job specification. In either case, actuator shall be able to withstand maximum shut-off pressure with the minimum instrument air pressure specified.

4.11.15 Control valve accessories such as positioner, air filter- regulator and solenoid valve shall be properly mounted on the actuator and shall be fully tubed.

4.11.16 Valve positioners wherever used shall be' side mounted force balance pneumatic type. For electronic instrumentation, I/P converter shall be used alongside pneumatic positioners. Separate I/P convertor and positioner shall be used unless specified otherwise. Separate air filter regulator shall be used for each valve positioner. Smart positioner shall be used where specified in job specification.

4.11.17 The I/P convertor shall be intrinsically safe certified and shall be of electronic feedback type. It shall have an integral junction box with 112" NPTF cable entry and be suitable for "2" pipe mounting.

4.11.18 The air filter regulator mesh size shall be suitable for I/P convertor.

4.11.19 Whenever limit switches are specified, as inductive proximity type, these shall meet NAMUR (DIN-I9234) requirements.

4.11.20 Separate limit switches shall be provided for open and close position, where required.

4.11.21 Solenoid valves, wherever used, shall be universal type and shall be continuous rated type with class F coil insulation as per IEC, 85/IS 1271. These shall be of brass body with $S316 trim, as a minimum.

4.11.22 Self actuating' regulators for flow, pressure and temperature shall be, used as indicated in P&ID.

4.11.23 Whenever fire safe requirement is specified for a shutdown valve, the valve body as well as the actuator' shall meet the testing requirements as per API 617 latest revision. In addition to above, air volume tank shall also be provided for a storage of air volume with minimum two full strokes of valves.
All valve accessories like solenoid valve, limit switches and, volume tank etc shall also be enclosed in a certified fireproof enclosure. The cable used for the actuation of the valve shall also be fire resistant (Fire Survival to me 331).

4.11.24 All valves in cryogenic service (i.e. the valves installed in piping classes used for temperature below -29°C>C) shall be designed and tested as per BS-6364.

4.11.25 Control valves/shutdown valves requiring certain specified operating timings; shall be tested before despatch for the specified 'operational time verification. Hook-up drawings along with the timing calculation shall be submitted by contractor for review.

4.12 Pressure Relief Valves and Rupture Discs

4.12.1 Pressure Relief Valves

4.12.1.1 In case, ASME section I valves are supplied, it shall have the certificate from ASME laboratories.

4.12.1.2 Pressure relief valves shall be full nozzle full lift type except for thermal relief valves.

4.12.1.3 Conventional valves shall be specified for constant back 'pressure while bellows seal type valves shall be specified for variable back pressure more than 10% of set pressure. Pilot operated pressure relief valves shall be used for special services and where set pressure is closer than* 10% of the operating pressure, in general.

4.12.1.4 Lifting lever shall be specified for steam and air service. Open bonnet shall be used for steam service.

4.12.1.5 The percentage accumulation in case of pressure relief valves/safety valves shall be as follows

a) Steam Service
   - ASME SEC I 3%
   - IBR (Before steam let-down station) 3%
   - IBR (Distribution & utilities) and 10%
   ASME Section VIII
b) Gas, Vapour or liquid except in (c) & (d) 10%
   below
c) Liquid for thermal Relief 25%
d) Fire exposure on unfired vessels 21%

4.12.1.6 3/411 x 1" threaded (NP'T) modified nozzle type valves with typically 0.38 cm² orifice size shall be specified for thermal relief.

4.12.1.7 The body material shall, as a minimum, be as per piping specifications. Nozzle and disc material, shall be SS316 as a minimum with machined stainless steel guide and spindle.
Whenever semi nozzle designs are unavoidable, body material shall be at least same as nozzle material.

4.12.1.8 The spring material of pressure relief valves shall be as follows unless otherwise necessary because of process conditions:

-29°C to 250°C : Zinc/nickel plated carbon steel.
Above 250°C : Tungsten alloy steel.
Below – 29°C : Stainless steel 316

4.12.1.9 Flanged connection shall be for standard sizes 111 or larger. Minimum flange rating shall be 150 # ANSI.

4.12.1.10 Where permissible, threaded connections shall be used on sizes 3/4” and below.

4.12.1.11 Pilot operated pressure relief valves shall have remote sense facility for pilot valve. Internal sensing for pilot shall be avoided as far as possible.

4.12.1.12 The pressure relief valves shall be type tested for capacity with 5% blow down as per ASME sec VII UG-131 and the actual blowdown of individual valves shall meet the process requirement. Contractor shall furnish the type test certificate for the same.

4.12.1.13 Test gage shall be provided for all pressure relief valves.

4.12.2 Rupture Disc

4.12.2.1 Rupture discs shall be reverse buckling type, in general and shall be supplied in pre torque holder assembly which shall fit inside the inner diameter of the bolt circle of standard ASME flanges. Disc material shall be compatible with the vessel contents and shall be consistent with the bursting requirements.

4.12.2.2 Following shall be taken care when rupture disc is valve:

(a) Derating factor of 0.9 shall be used for capacity rating

(b) A tell-tale assembly consisting of pressure switch, pressure gauge and excess flow check valve shall be provided to indicate leakage/rupture downstream of the rupture disc.

4.12.2.3 Manufacturing tolerance of the rupturedisc shall be decided by contractor based on operating pressures. However when rupture disc is used in combination with pressure relief valve, zero manufacturing range shall be selected.

4.12.2.4 For each rupture disc four(1+3 spare) discs shall be provided.

4.13 Pressure reducing stations & Desuperheaters

4.13.1 The design of the desuperheater shall be based on the capacity and rangeability requirements to meet heat & mass transfer equation. Contractor shall also ensure the following while sizing & designing the system apart from other considerations:

(a) turndown of desuperheaters and coolant

(b) minimum velocity requirements
(c) allowable pressure drop
(d) minimum pipe straight run required, upstream & downstream.
(e) location of temperature sensor at downstream
(f) design of control scheme

4.13.2 The desuperheaters shall be of insertion type design, in general, and shall consists of a coolant injection assembly with sleeve and atomising nozzles inserted perpendicular to the 'process line. Other types including in line mounted desuperheaters 'like variable orifice nozzle etc. shall be used based on process conditions.

4.13.3 Temperature control valve in the coolant line shall be integral to the desuper heater, in general. Whenever separate control valve is necessary, its design, sizing, compatibility and suitability with the desuperheater shall be ensured.

4.13.4 Whenever pressure reduction is also required with desuperheating, integral design of desuperheater with pressure reduction shall be offered unless otherwise specified.

4.13.5 The desuperheater and the pressure reducing control valve's body rating shall be equal to or better than the flange rating as per piping material specification.

4.13.6 The, insertion type desuperheater shall be suitable for mounting on 311 size flanged nozzle.

4.13.7 The material of all wetted parts shall be suitable for the process being handled at its operating, and design flow, pressure and temperature.

4.13.8 The desuperheater shall be sized to maintain temperature at the’ outlet of the desuperheater within ±5 °C in general.

4.13.9 All accessories like positioner, air filter regulator shall be firmly mounted on the actuator and shall be fully tubed. Actuator shall be fully tubed. Actuator shall be pneumatic spring opposed diaphragm type in general. Positioners shall be side mounted force balance type. I/P converters shall be used along with pneumatic position Separate air filter regulator regulator shall be used for each valve positioned.

4.14 Tank Safety System

4.14.1 Tank safety system shall be provided as' per P&ID and shall be designed considering the safety requirements related to over-pressurisation and excessive vacuum generation in the tank because of normal pump in, pump out conditions, fire conditions, sudden depressurization and condensation/contraction of vessel vapours during sudden atmospheric thermal cooling. The system shall consist of tank blanketing equipment, breather valve, emergency vent and flame arrestors as applicable.

4.14.2 The total system design shall take into consideration the blanketing pressure and the tank design pressure/vacuum. The operating margins should, be sufficient for each device to operate independently. Design shall also avoid undesirable operation of breather valve under normal pump in, pump out condition and operation of emergency vent under breather valve operation unless absolute necessary as per process requirements. A minimum gap of 35% should be ensured between set pressure of breather valve and emergency 'vent for proper operation(considering design of breather valve with 20% overpressure).
4.14.3 The blanketing scheme shall be specially designed considering normal and maximum blanketing flow and shall comprise of self actuated control valve (PCV) assembly designed specially for blanketing application. Conventional PCV or set of PCV's shall not be offered as a replacement to blanketing assembly. For the tanks or vessels with higher set pressures alternate scheme of pressure control valve with split range control valve of sufficient size, can also be accepted if specified in the P&ID.

The flow capacities of the blanketing systems shall be established as per procedure defined in API-2000. The blanketing system selected should have published regulating characteristics to establish its suitability for the requirements. Wherever an external pressure sensing is necessary it should be taken directly from tank.

4.14.4 The type of breather valve i.e. close vent or open vent type shall be selected based on the P&ID requirements and shall be sized to consider overpressure and vacuum requirements for which a separate pallet shall be used. The breather valve shall generally be dead weight, soft seated type with teflon diaphragm and shall have self draining body construction.

Spring loaded type can be used where dead weight design is not feasible. The selected valve design shall ensure that seating surface is shielded from direct liquid/condensate flow to prevent tendency of pallet sticking. A test connection below pallet shall be provided for breather valve testing. The breather valve selected shall have certified flow capacity as per API-2000.

4.14.5 The emergency vent shall be hinged cover type with weighed pallet and shall open to atmosphere. Services where ventilator not be discharged freely to atmosphere, spring loaded design also shall be acceptable. The selected vent shall have certified flow capacity as per API-2000.

4.14.6 The type of flame arrester i.e. detonation/deflagration shall be selected as per actual installations requirements and shall meet the requirements of BS-7244. The flanged type of flame arrester shall be selected in general. Whenever end of line flame arrestors are selected it shall always be provided with a free vent having SS316 mesh. The sizing of the flame arrester shall be carried out considering maximum delta pressure drop allowable across the flame arrester flame arrester-vent combined. The flame arrester shall be certified for the capacity as per API-2000 as well as the gas group classified as per BS-7244.

4.14.7 Where no free vent is provided for the valves /flame arrestors installed at the end of line, goose neck vent shall be installed to prevent entry of rainwater/birds, Mesh shall be provided at the end of the goose neck, Compressor Instrumentation

4.15.1 Contractor/compressor vendor shall be completely responsible for providing adequate instrumentation for safe and efficient operation of the machine. The commonly used instruments are being detailed out in the following clauses, however this does not absolve the contractor of providing additional instrumentation, if required.

4.15.2 Anti-surge Control System (ASC)

4.15.2.1 Contractor/compressor vendor shall be fully responsible for the complete design of anti-surge Control system including selection of type of flow element, controller algorithm, type of explosion protection, type and operating timings of final control element. Vendor shall guarantee the performance of machine with the offered ASC System. Whenever required ASC system shall be designed in such a WWJ that it is capable of detecting surge well in advance and correct the compressor operating point accordingly so as to avoid surge in order to protect machine from possible damage, to minimise process upsets and to minimise recirculation.
4.15.2.2 ASC System shall typically consist of but not limited to flow element, flow transmitter differential pressure transmitter, ASC controller, control valve and other accessories as felt necessary by the vendor.

4.15.2.3 Vendor shall supply all hardware and software related to the operation and safety of the compressor. This shall include but not be limited to the following:

a) Design and operation of surge control loop scheme based on offered compressor performance.

b) Supply of all hardware in anti-surge control loop including dedicated controller, transmitters, measuring elements, final control element etc.

c) Fast response transmitter and control valve etc. as required.

d) Algorithm required for Anti Surge Controller.

4.15.2.4 Dual redundant link shall be provided to interface ASC system with DCS 'for all operational data required at DCS.

4.15.6 Vibration and Axial Displacement Monitoring

4.15.6.1 Vibration and axial displacement monitoring system shall be based on non-contacting type sensing probe, unless otherwise specified.

4.16.2 Vibration and displacement monitoring system shall be as per API-670. The extent and type of monitoring shall be as defined elsewhere. However, contractor shall furnish any additional requirements for monitoring deemed essential by them with reasons. Two probes at 90 degrees apart for each location shall be provided and connected to same dual channel monitor for vibration monitoring.

4.16.3 The sensing probe shall be accessible' for adjustment, repair and replacement without dismantling the machine:

4.16.4 Vibration and displacement monitoring system shall be Bently Nevada 3500 series or equivalent. Monitoring instruments shall be located in control room 'unless otherwise specified.

4.16.5 System shall provide continuous 4-20 mA DC isolated output for each channel of measurement for remote indication and potential free contacts for all shutdown setting.

4.16.6 Monitors shall be with maximum four (4) channel type and shall meet the following specifications as a minimum:-

a) Each channel shall have two independent alarm levels one for pre trip alarm and one for each trip, settable continuously over measurement range. Two relay contacts for each pre trip alarm and trip alarm per channel shall be provided.

b) Broken sensor failure detection without causing shut down.

c) LED status indication to show health status of the monitor, bypass status and communication status of the monitor.

4.17 Speed Monitoring

4.17.1 Speed monitoring system shall be based on non-contacting type sensing probe, unless otherwise specified.
4.17.2 Speed monitoring system shall be as per API-670. The extent and type of monitoring shall be as defined elsewhere. However, contractor shall furnish any additional requirements for monitoring deemed essential by them with reasons. Two probes at 90 degrees apart for each location shall be provided and connected to same dual channel monitor for vibration monitoring.

4.17.3 The sensing probe shall be accessible for adjustment, repair and replacement without dismantling the machine.

4.17.4 Speed monitoring system shall be Bently Nevada 3500 series or equivalent. Monitoring instruments shall be located in control room unless otherwise specified.

4.17.5 System shall provide continuous 4-20 mA DC isolated output for each channel of measurement for remote indication and potential free contacts for alarm/shutdown setting.

4.17.6 Monitors shall be with dual channel type and shall meet the following specifications as a minimum :-

   a) Each channel shall have two independent alarm levels one for pre trip alarm and one for each trip, settable continuously over measurement range. Two relay contacts for each pre trip alarm and trip alarm per channel shall be provided.

   b) Broken sensor failure detection without causing shut down.

   c) LED status indication to show how health status of the monitor, bypass status and communication status of the monitor.

4.18 Bearing and Winding Temperature Monitoring

4.18.1 In general, bearing temperature shall be measured at the points which are under maximum loading.

4.18.2 Sensor shall be three wire RTD element of platinum having 100 Ω at 0°C. Calibration shall be to DIN 43760 standards.

4.18.3 The temperature sensor cables, terminal heads, junction boxes etc. should be capable of withstanding the mechanical vibration and environment of a rotating machinery atmosphere.

4.18.4 Bearing and Winding temperature shall be monitored by means of a temperature monitor. The temperature monitors shall be located in control room and shall meet following requirements :-

   a) Accept RTD inputs (platinum, 100Ω at DIC calibrated to DIN 43760 standards).

   b) Continuous six channel monitoring with each channel input from one RID.

   c) Each channel shall have two independent alarm levels one for pre-trip alarm and one for trip alarm, settable continuously over measurement range.

   d) Broken sensor failure detection without causing shut down.

   e) LED status indication to show how health status of the monitor, bypass status and communication status of the monitor.

   f) Analog output 4-20 mA DC isolated signals shall be provided for each channel for remote indication.
4.18.5 Separate temperature monitors shall be provided for motor winding and bearings temperature monitoring.

4.19 Key Phasor

4.19.1 Key phasor systems shall be provided by vendor for performing analysis of vibration signals to determine machine malfunctions. It shall consist of a proximity probe and transmitter, extension cable, mounted etc. and other accessories to make the system complete. Vendor shall provide necessary reference on the shaft to determine one-per-turn occurrence.

4.20 Accumulator of Lube Oil System

4.20.1 If accumulators are used with, nitrogen for lube oil dampening at the desired pressure to meet the system requirement the following instrumentation with the accumulator to be provided by vendor :-

   a) Accumulator shall have charge kit with isolation valves and connection hoses.

   b) Standard Nitrogen cylinders available in India are at pressure of 140 kg/cm² with standard connection sizes. Vendor shall provide the complete regulator System with protection for charging nitrogen from nitrogen cylinder to accumulator at the desired pressure. Regulator shall be suitable for the inlet pressure variation of 140 to 150 kg/cm² while charging with suitable inlet connection to match the Nitrogen cylinder connection. Regulator system shall have pressure indicator, regulator, relief valve, needle valve etc. as "a minimum. Material of construction shall be stainless steel.

4.20.2 The compressor loading-unloading scheme for reciprocating compressors shall be provided as per the minimum requirements specified in the job specifications. Manual as well as automatic schemes shall be provided per steps as per machine requirement.

4.20.3 Emergency switch shall be provided in the local panel/field. All such switches shall have a protective cover to avoid inadvertent shutdown.

4.20.4 Vendor shall provide the following common alarms in control room:

   a) Common machine pre-trip alarms.

   b) Common machine trip alarm.

4.20.5 Vibration, axial displacement, speed, temperature monitoring system shall be provided with serial link output for connectivity to plant DCS. The serial link shall also be provided for machine diagnostic software running on separate whenever specified in job specification.

5. CLOSED CIRCUIT TELEVISION (CCTV) SYSTEM

5.1 Functionally CCTV system is required for the surveillance of the plant and equipment as detailed out in job specification.

5.2 All the cameras shall have Pan and Tilt control. The camera viewing angle can be varied between 70 to 400 and shall have zooming facility.

5.3 The CCTV central unit shall be located in the main control room or satellite rack-room as required. Separate monitors shall be suitably located in console area and keyboard, joystick etc. shall be located on the hardwired console unless otherwise specified in job specification.
5.4 The minimum enclosure protection degree of the system components Shall bem accordance with me 529 as follows:

a) Outdoor IP 65  
b) Indoor IP 42  
c) Panels with open doors IP 20 (live parts shielded)

5.5 Control unit and all peripherals shall be installed in' air conditioned main control room. Cameras shall be installed outdoor in the field. Cameras with its accessories shall be housed in explosion proof certified Ex’d’ housing suitable for gas grouping of the plant.

5.6 The system shall include all hardware, wiring, cabinets, materials and application software for a fully function system. Components shall be for industrial grade.

5.7 Cameras shall be as a minimum, comply with the following specification:

a) Pick up element: ½, 1/3” interlined CCD Colour
b) Picture point: 512 x 582

c) Sampling system: PAL Standard CCIR 625/50 lines per frame
d) Video band with: 5 MHz = -3dB
e) Horizontal resolution: Minimum 450 lines
f) Sensivity: 3 lux for a good picture (@F = 0.95 and 3200 K)
g) Zoom lens: 11-66mm
h) Controls: Zoom, Focus, Iris and external synchronization
i) Signal noise ratio: Approx. 50 dB
j) Gamma: 0.5
k) Automatic light: 1:10

level control

l) Temp. range: 5-80°C
m) Video output 1 V peak: 75 Ω unbalanced to peak
n) Camera identification: Yes

Automatic gain control facility: Yes

The zoom objective shall be equipped with an automatic diaphragm control, auto focus and spot filter.

5.8 The time lapse Video recorder shall be as below unless mentioned otherwise:

a) Cassette Tape: Standard 2 hour ½" S-y VHS E-120 or E-180
b) Record / play back speed : 2, 12, 24 and at least upto 72 hours  
c) Video input / output : 1 V peak to peak 75 Ω unbalanced.

5.9 Movable camera shall have an electric control mechanism (pan and tilt) which shall be controllable through a joystick and the same shall located on the hardwired console. The pan and tilt shall comply with the following:

a) Angular travel : Pan 0-335 degrees, Tilt ± 90 degrees  
b) Stops : Externally adjustable  
c) Speed (no load) : Pan 6 degrees/second, Tilt 3° degrees/second  
d) Loading : Suitable for camera and camera housing

5.10 Outdoor cameras and accessories shall be housed in an Ex'd' and ingress protected (IP 65) housing. Sand protector, wash and spray installation on the lens cover shall be provided. A sun cap shall prevent direct sun radiation into the lens and camera housing. The enclosure shall be epoxy painted.

5.11 Cameras with its accessories shall be installed on steel structure (mounting poles) Mounting pole/structure shall be 10 metre high (minimum and shall be designed for maximum wind velocity of the plant location. The allowable deflection at the top shall be ± 5 mm. The mounting pole/structure shall be supported on a concrete foundation. A ladder shall be provided to access the camera at top for the purpose of installation and maintenance of camera and its accessories. The design, supply, fabrication and erection of poles including its support arrangement shall be in contractor's scope. The structural steel shall be epoxy painted to meet the environment.

5.12 a) From a master control panel (keyboard) it shall be possible to select any camera and display the picture at the monitor:

b) Remote control panels/keyboard shall be programmed for the control of selected cameras with the possibility to call up any camera connected to the system.

c) Commands from the control unit are sent via a data transceiver to the control receiver at the camera side. The control receiver will control the camera lens and pan/tilt functions.

d) Operator shall be able to control all cameras and pan, tilt and zoom functions manually.

e) The Video recorder shall record the activities at all entrances and at locations where alarms have been alerted. The time lapse video recorder(s) shall be able to record up to 72 hours without reloading.

f) It shall be possible to view pictures of four cameras or three cameras and VCR simultaneously on the screen. Suitable quad unit shall be provided.

5.13 Wiring and connection shall be as below unless specified otherwise:

a) All the cables (indoor/outdoor), connectors and plugs shall be supplied. The connectors shall be BNC type.

b) Flexible cables shall only be used for flexible connections.

c) Video signals from cameras to the control unit shall be transmitted via coaxial cables.
d) Camera control signals x-ray be transmitted either via twisted pair or via multicore cables.

e) All interconnection cabling between field mounted cameras to control equipment shall be shielded and armoured. Outdoor cabling between control equipment/ monitor / key board and optical fibre cable shall also be shielded and armoured.

f) Materials shall be of proven design for similar application.

5.14 All the outdoor items shall be tropicalized and epoxy painted. All carbon steel bolting shall be hot dip galvanized or Cadmium plated and bi-chromated, Screws, rivets, brackets and stiffeners shall be stainless steel. Colour of the top coat of panels shall be manufacturer standard.

6. CONTROL ROOM REQUIREMENTS

6.1 The control room required for housing control system and other instrument items shall be designed, constructed totally by contractor. The following shall be considered as minimum for control room.

a) The control room shall be common for all units with respect to consoles, however rack room may be common or segregated as per satellite rack room concept.

b) The control room shall be so designed as to have console area for DCS and hardware consoles fire alarm panel which requires 'direct operation intervention and rack area sharing atleast one of the wall within the console room to house all racks, cabinets etc.

c) A separate room shall be provided for EC (Engineering Consoles) / PLC consoles.

d) The rack room and EC/PLC room shall have connectivity with console room.

e) All the room shall have false flooring and false cing unless otherwise specified.

f) The control room shall be illuminated adequately with glazed lighting arrangement which shall not cause any glare at viewing area. The lighting arrangement shall be approved by Purchaser/purchaser's representative.

g) The console area and rack area shall be separated by solid partition. Painting and finish of floor and colour of consoles/racks shall be aesthetically matched.

h) The main entry to the control room/console area and equipment entry to rack area shall have door opening 2500 mm (W) X 2700 mm (H) (clear space), double door. Escape route for console / rack room shall be provided.

i) The UPS and other electrical equipments shall be housed in UPS room with separate cable entry. In general no electrical equipment shall be placed at rack area.

j) In the console area consoles shall be arranged in an arch form or straight. Ergonomic techniques shall be used in design and layout of the consoles based on the assumption that operators are seated while using the keyboards CRT displays, keyboards HW switches other console equipments. A minimum clearance of 2 metres at the back side wall to console and 3 metres at the front shall be kept.

For arch type console minimum of 2 metres from the tip to the front wall shall be considered on either side.
6.2 For rack room, the layout shall be made considering the following.
   a) Clearance between back and front rows from wall shall be 1.5 m (minimum).
   b) Clearance between 2 rows shall be equal to 1.4 m or DCS vendor's recommendation whichever is higher.
   c) Clearance between all rows from side walls shall be equal, to 1.5 m (minimum)

6.3 The console area shall be sized to accommodate consoles for future units to be installed by owner at a later date if specified in job specification. The channel base shall be provided based on base frame details to be provided during detailed engineering.

   The sizing for rack room shall be made in such a Wtrj that 30% spare cabinet space available for future use.

6.4 All consoles, racks, in control room and E C / PLC room shall be bolted on in to channel bases which is grouted to the floor.

6.5 The printers shall be arranged in console area.

6.6 All cabling inside the control room shall be done through trays below false flooring. No cable shall be left on the floor.

6.7 Contractor shall obtain specific approval on control room equipment layout before proceedings for control room engineering.

7.0 DISTRIBUTED CONTROL SYSTEM

7.1 The Control System (DCS/PLC) shall follow the specifications as per 1071-6-52-0055 Standard Specification for Distributed Control System. the specific requirements given in this specifications and special requirement given under job specification. Plant operational requirements shall be as per P&IDs. Process description and any other requirement as defined in Process package.

7.2 The offered control system shall have complete infrastructure, 'base available' in India for the purpose of maintenance. spare parts supply engineering support, expansion etc.

7.3 If at any point of time during execution of job, DCSI PLC system as being supplied is found inadequate additions/modifications required in software or hardware to meet the requirements shall be carried out by contractor without any time/cost implications.

7.4 Functionally, the plant monitoring, control etc. shall be done through DCS and the interlock/shut down is executed through PLC, in general. Inter mixing and interchanging of functionalities are not allowed.

7.5 For the overall plant operational philosophy, number of control systems, their locations, the Process units under each System, the connectivity between other control systems etc. the system configuration and other requirements given in Job Specifications attached elsewhere shall be referred and met with.

7.6 Process unitwise segregation shall be provided for controller/data acquisition sub-system, PLC, Marshalling/barrier and termination cabinet, relay rack, electrical instrument interface cabinet, power distribution.
7.7 In case of bulk power supply used for powering 2 wire transmitters, barriers etc, the dual redundant power supply shall be provided.

7.8 Control room ergonomics shall be considered while deciding the various operator/engineering interfaces. Unless otherwise specified all operator/engineering interfaces shall be console type. Only single tier shall be considered unless specifically indicated otherwise in the job specifications.

7.9 Controller and data acquisition sub system

7.9.1 i) Unless otherwise specified, plant control and data acquisition functionality shall be carried out in the 32 bit microprocessor based controller. and data acquisition subsystem. A multidrop controller sub-system shall be utilised with 1:1 redundancy including communication sub-system, I/O modules, power supply modules, processor modules etc. within the system

   ii) The controller shall have the following library of algorithms available as their firmware, as a minimum:

   General
   Control Algorithms
   Arithmetic function
   Linearisation
   Linearisation and cold junction" compensation, RTD Linearisation, Polynomial
   Dynamic function
   Limiter function
   Comparison functions
   Selector functions
   Logic functions
   Miscellaneous

   iii) In addition, the controllers and data acquisition sub system shall have the following features:

   a) Output status on controller failure shall flunk/freeze and shall be engineer configurable.

   b) Configuration and tuning shall be from centralised level (operator/Engineer station).

   c) Anti reset wind up feature and reverse/ direct selection.
d) Control modes shall be auto, manual, cascade, computer.

e) It shall support various types of input-output signals which are 4 - 20 mA DC - 2 wire and non 2 wire, 1-5 V DC, thermocouple (all types) grounded or underground as per IEC 584-2, RTD Pt.100, 3 Wire or 2 wire as per DIN 43760, contact (volt free), BCD, pulse etc. inputs. 4-20 mA DC, digital output (volt free contact) or any other output as specified.

All I/O modules shall have galvanised isolation.

f) The memory for configuration shall be resident in controller and data acquisition sub-system itself and shall be retentive. In case the memory is volatile, chargeable battery back up shall be provided for retention of configuration for 72 hours in case of loss of power to the sub-system.

g) The online diagnostic message shall be available at centralised and local level.

h) The switch-over time’ from primary to back up controller and vice-versa shall be of the order of one second. In case of failure of primary controller

i) The system shall be capable of supporting remote I/O's. However, local I/O configuration shall be used, unless specifically indicated otherwise 'in job specifications.

k) Cable loop resistance of 80 0 (which is equivalent to 1000·M of loop resistance of 0.5 mm² cable) shall be considered as default value for deciding interrogation voltage or transmitter power supply.

7.10 COMMUNICATION SUB SYSTEM

7.10.1 The communication sub system which extends outdoor shall be through redundant fiber optic cables. The optical fibre cables or any other system cables shall be of armored type or shall run in GI (galvanised, iron) conduits. Separate duct shall be provided for the data highway and system cables. The redundant cables shall follow separate cable routings. The fiber optic cables shall be provided with wire armouring, If tape armouring is used, it shall be corrugated steel tape armour with double layers of steel tape armouring. The fiber optic data highway cable shall have separate cables for redundancy with numbers of fibres per requirement. Additionally 4 nos. spare fibre shall be provided.

7.11 Operator interface subsystem shall be industrial grade work .station based and' shall be sourced from Original Equipment Manufacturer (OEM).

7.11.2 The system shall be capable of providing the following logging function as minimum for all tags.-

- Alarm History per shift
- Event logging
- Hourly, weekly, daily log reports
- Shutdown reports
- MIS (Management Information System) Reports
- Trip initiated log reports
- Rotary equipment running data etc.

The log formats shall be user definable and shall be finalised during detail engineering.

7.11.3 Operator interface sub system shall be an independent function sub-system and shall not depend on any other node/sub-system including engineering interface sub-system under normal operating condition.

7.11.4 Number of graphic pages per console shall be 300 as a minimum.

7.11.5 Minimum two cursor control devices shall be provided on each CRT one keyboard other touch screen or track ball or any other as specified in job/particular specifications. The touch screen provided shall operate only when the finger (or any other device) touching the screen target is withdrawn: It shall not operate on mere touching.

7.11.6 Window operation

a) The operator interface sub system shall have facility to open multi-corridors on the operator console for the wider look of the plant. It shall be possible to operate the plant through any of these windows.

b) The system shall have capability to provide multi-window display without erasing the current display panel by opening up multiple drag and drop rectangle window on the screen. The following type of window display and function shall be provided.

- Alarm Window
- Face plate window
- Trend window
- Process window
- Graphic window
- Menu window

c) The system software shall restrict operator to open more than four windows at a time.

7.11.7 The system shall have capability to configure 600 graphic pages. However contractor shall include pre-configuration of at least 300 graphic pages unless otherwise specified.

7.11.8 Ergonomic techniques shall be used in the design and layout of the consoles based on the assumption that operates are seated while using the CRT displays, keyboards, hardwired switches and other console equipment. Also, note that there shall be no limitation with respect to specific structural arrangement - semi-circular, horse shoe etc.

7.11.9 Operator consoles shall have non-volatile memory for configuration and storage.

7.11.10 Design of graphic displays shall be as per ANSI/ISA-S5.5 Graphic Symbols for Process Displays" and as per drawings provided by Owner! Owner Representative.

7.11.11 The system status display on each of the consoles shall provide indications for CPU loadings / memory loading, and mass storage devices utilization of each of the subsystems in addition to those specified under 5.3.5 of the Standard Specifications 1071-6-52-0055.
7.11.12 Two audible alarms distinguishable from one another, each having adjustable volume control shall be provided with system. One for selected non-critical alarms and the other for critical alarms. Spare dry contacts shall be wired in parallel with audible alarms. Both the audible alarms and the respective auxiliary contact outputs shall be silenced/acknowledged from any of the operator keyboard assigned for the operation of that unit.

7.11.13 The operator console shall have four (4) alarm priorities. One alarm shall be for events, second for non-critical alarms, a third for critical alarms and a fourth for system alarms. Contractor shall state in their proposal if the offered system has dead band fixed or adjustable, on analog input alarms. The operator should be able to mask or group of alarms. A list of suppressed alarms shall be available to the operator.

7.11.14 One number of engineering keyboard shall be provided for each operator console.

7.11.15 The keyboard security against unauthorized entry with key lock and password shall be provided for each keyboard of separator/engineering consoles.

7.11.16 The following are the maximum number of keystrokes required for accessing a view as per standard display hierarchy:

<table>
<thead>
<tr>
<th>Type of view</th>
<th>No. of key strokes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group view</td>
<td>2</td>
</tr>
<tr>
<td>Loop view</td>
<td>3</td>
</tr>
<tr>
<td>Loop in alarm</td>
<td>2</td>
</tr>
<tr>
<td>Graphic View</td>
<td>2</td>
</tr>
</tbody>
</table>

7.11.17 For CRT display the following additional requirements shall be considered.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Least</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of background colour</td>
<td>7</td>
</tr>
<tr>
<td>No. of foreground Color</td>
<td>7</td>
</tr>
<tr>
<td>No. of display characters</td>
<td>80</td>
</tr>
<tr>
<td>No. of character types</td>
<td>Min - 96 ASCII characters</td>
</tr>
<tr>
<td>Characters Construction</td>
<td>Character 5x7 dots Pattern 7x8 dots</td>
</tr>
</tbody>
</table>

7.11.18 Number of trends per display shall be minimum 4.

7.11.19 The system shall be provided with a minimum of 32 user definable function keys to call up the preselected display from each operator station.

7.11.20 Assignable trend recorders shall be provided for each console with the following:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of points to be recorded</td>
<td>Sixteen (min) user selectable</td>
</tr>
<tr>
<td>No. of pens/ recorder</td>
<td>4 or 6</td>
</tr>
<tr>
<td>Recorder size</td>
<td>6&quot; x 3&quot;</td>
</tr>
<tr>
<td>Chart size f speed</td>
<td>250 mm adjustable set at 50 mm/h.</td>
</tr>
</tbody>
</table>
7.12 Hardware console

7.12.1 a) The layout of the hardwired console shall match with the operator console layout. Any non-DCS CRT required to be placed along with operator console, should be on the hardwired console and shall match with the operator console ergonomics.

b) The plant communication system console, CCTV keyboard/CRT's etc. shall be installed in the hardwired console.

7.12.2 All Hardwired (HW) items like Push buttons, lamp annunciator etc. shall be of miniature type. The emergency Push buttons shall be of mushroom type unless specified otherwise.

7.12.3 All push buttons/selector switches as indicated/required in trip diagrams (manual reset of trip, manual activation of trip, control room reset for solenoid valves etc., auto start/stop logic for pumps and other packages shall be indicated on hardwired consoles(HWC) layout drawing with appropriate tag nos. And legends

7.12.4 For all 2 out of 3 voting logics as indicated in the P&ID and other specification. Contractor shall consider one common hardwired alarm annunciation in the HWC and individual alarm in DCS.

7.12.5 All Hardwired items like push buttons, lamps, annunciator shall be of miniature type.

7.13 HART MAINTENANCE SYSTEM

7.13.1 HART maintenance system shall be supplied by the contractor for smart instrumentation like transmitters, positioners etc. The system shall be located in the control room and shall have compatible software like Cornerstone Asset Management or equivalent.

7.14 Wiring /Termination

All interconnection between field and control room shall be from Marshalling racks only. All interconnection between marshalling racks and system cabinets shall be through prefabricated cables with plug-in-connectors at both ends.

7.14.1 In all analog marshalling cabinets provision shall be kept for mounting a hand held communicator for smart transmitter.

7.14.3 All interconnecting cables between cabinets/printer/console etc. shall be armoured or run through conduits to protect from rodents.

7.14.4 All cabinets, panels, racks must be designed to avoid congestion for ease of maintenance. All spare cores of multicables shall be terminated on the marshalling rack next to the assigned cores.

No cables/cores shall be left un-terminated in the rack/cabinet. Also no terminal or terminal strips shall be located on the side panels of the rack/cabinet.

7.14.5 Rack layout shall ensure clear and adequate segregation between termination panels, I/O modules and cables in the following:

- Analog (non-intrinsically safe)
- Discrete (intrinsically safe)
- Discrete (non-intrinsically safe)
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- Power supply cables (voltage wise split)
- My signals
- Pulse signals
- RTD signals

7.14.6 Not more that four cabinets shall be combined for wiring. For consoles and cabinets, side cover shall be provided individually.

7.14.7 All wiring shall conform to API-RP-550 Part I section 7 and 12. Different signals level cables shall be routed under false flooring with separation distance as recommended by API-RP-550 section-7.

7.14.8 All wiring inside racks, cabinets and back of the panels shall be housed in covered, non flammable plastic raceways arranged to permit easy accessibility to various instruments for maintenance, repair and removal.

All wiring in the race ways shall be properly clamped. Total wiring cross-sectional area including air gap shall not exceed 50% of the raceway cross-sectional area. Rubber/Plastic grommets shall be used for wire entry into individual instruments 'and entry/exit of wires through raceways. The exposed length of wiring shall be kept minimum.

7.14.9 Separate wiring raceways shall be used for power supply wiring DC and low level signal wiring, and intrinsically safe wiring. Parallel runs and AC and DC wiring, closer than 300 mm shall be avoided.

7.14.10 Wiring termination shall be done using self crimping lugs.

7.14.11 No more than-two wires shall be terminated on one side of single terminal. Such a practice shall be avoided as far as possible. The use of shorting links for looping shall be avoided.

7.14.12 Cable glands shall be provided for all cable entries to the cabinets/racks/consoles.

7.14.13 Terminal housing shall be strictly sized with considerations for accessibility and maintenance. Following points should be considered.

a) Distance between terminal strip and side of the cabinet parallel to the' strip upto terminals shall be equal to 50 mm (min.)

b) Distance between terminal strip and top and bottom of the cabinet shall be equal to 75 mm (min.)

c) Distance between two adjacent terminals shall be equal to 100 mm (min.)

d) Addition distance for each additional terminal shall be equal to 25mm (min.)

e) Distance between cable gland plate and bottom of the strip shall be equal to 300mm (min.)

7.14.14 All terminal strips shall be mounted on suitable anodised metallic or plastic stand off.

7.14.15 No spacing is allowed in between wire/cable straight run.
1.14.16 Terminal strips shall be arranged group wise for incoming and outgoing cables separately. 30% spare terminals shall be provided as a minimum.

7.14.17 Cabinet and rack layout shall be made considering proper accessibility and maintenance, 20% spare accessories like relays, switches, barriers, lamps, fuses etc shall be provided completely wired as a minimum.

7.14.18 Terminal blocks for intrinsically safe wiring shall be separate.

7.14.19 Thermocouple extension cables shall be used for thermocouple signals with in control room.

7.14.20 All trip connected' ferrules in the marshalling racks shall be of red colour. both from the field and to the field.

7.14.21 For internal signals wiring in the cabinets and accessories, flexible stranded, PVC insulated, twin twisted and shielded Copper conductor shall be used. For signal wiring external to the cabinet 1.5 mm² twin twisted individual shielded, overall shielded with overall drain PVC insulated and armoured cables shall be used.

For power supply (UPS), min. x C x 2.5 mm² PVC insulated and armoured Copper conductor shall be used.

7.14.22 All terminals shall be mechanical screw clamp type with pressure plates. Terminations shall be done using self insulating crimping lugs. Wire lugs shall be used for all terminations on terminal blocks, where as forked tongue' type lugs shall be used for termination, on screw terminals such as, a relays, alarm annunciators, push buttons, lamps etc. Terminals shall be suitable to accept conductor size as a minimum

7.14.23 Additional terminals shall be used for looping if necessary. The use of shorting links for looping shall be avoided.

7.14.24 Sockets for all types of power available in the cabinet shall be provided far maintenance, work.

7.14.25 Wiring colour code within the cabinet framework and accessory equipment shall be as follows:

- Power Supply (line) Red
- Power Supply (neutral) Black
- Ground Green
- Alarm System White
- Control and shut down Yellow
- Analog signal intrinsically Light Blue
- Safe wiring Red (Positive)
- DC Wiring Red (Negative)
100 metre length of wires shall be supplied as loose spares for each cabinet column / row used.

7.15 Identification and Marking

a) All electrical termination's and equipment on the cabinet and other accessories shall be identified with appropriate tag, cable marker, etc.

b) All terminals in a terminal strip shall be identified by their individual numbers located integral with the terminal itself.

c) Interconnecting multicables shall be, identified by metal tags as indicated in cable schedules.

d) Wiring at terminals shall be identified by the terminal number and termination service at the other end of the wire. Wiring at instruments and accessories like alarm relays, push buttons etc. shall have ferrules indicating tag number; terminal number and the termination service at the other end of the wire.

e) Looping connections shall be identified by termination services at both ends of the wire.

f) Identification markets as mentioned above shall be repeated in contractor drawings.

g) Sample, identification methods shall be discussed with Owner before finalization.

7.16 Printers and hard copy unit

7.16.1 Logging/Alarm and Event/Configuration and maintenance Printer

a) Type of Printer shall be Line for logging printers and serial for others.

b) Number of character shall be approx. 96 and type shall be ASCII.

c) Printing speed shall be 300 lines per minute for logging printer and m in 120 characters/sec. for others.

d) No. of print columns shall be min. 132 character per line.

e) Paper width is approx. 381mm.

f) Paper type shall be continuous fan fold.

g) Number of copies shall be three.

h) Bi-directional printing feature is required for alarm and event printers and configuration and maintenance printers.

i) Acoustic cover is required for the printers.

j) Paper feed shall preferably be friction feed.

k) Test pattern generation is required.

l) Mounting shall be self contained with integral stand.
m) Noise level while printing at 1 meter distance shall be less than 45 dBA.

n) Identification as alarms and events is required by dual colour for alarm and event printers.

7.16.2 Hard Copy Unit

a) The hard-copier unit shall be electrostatic type or thermal type and shall be able to take coloured copies of any CRT screen either from operator console or from engineering console.

b) No CRT screen shall be locked out while taking copy. In case this is available its should not be more than five seconds maximum.

c) The number of channels shall be selected by contractor as per number of CRTs of operator console and engineering console of the system.

d) The hard copier shall be installed on a self contained integral stand.

e) Where there is a possibility of transfer of high voltage to communication sub-system from video copier, high voltage protection barriers shall be provided.

8. ANALYSER SYSTEM

8.1 This clause specifies the general requirements of process and flue gas analysers Application related specific requirements shall be described in job specification

8.1.1 Process Analysers

8.1.1.1 System Design

The principle of operation shall be simple in design and shall avoid analytical complexity associated with development of information which is extraneous to the application. In general, system shall consists of probe, sample tube, pressure reduction, sample conditioning, fast loop operation, analyser and vent connection to flare.

8.1.1.2 Probe: As recommended by analyser sub-vendor with isolation valve and material suitable for the application.

8.1.1.3 Sample tube: sample tube material shall be suitable for process condition with size as recommended by vendor. The samples consisting of condensable vapour shall be with electricity traced sample tube with temperature control.

8.1.1.4 Sample conditioning system: Generally sample conditioning system shall be as per API, meeting analysis requirement. The pressure reduction where required shall be provided with a safety valve at its down stream. Variable area flow-meters shall be provided for fast loop. For the stream where solid particles are expected, necessary filters shall be used Provision for necessary condensate knockoff system shall be provided, if applicable.

8.1.1.5 Analyser: The type of analyser shall be as per P&ID and process data sheets attached with the process package. The analysers shall be installed in that analyser shelter/room in general. In case where no analyser shelter exists, the analyser- shall be installed in a free standing analyser cabinet. The analyser cabinet shall be provided with a vortex cooler or air conditioning unit suitable for the area classification.
Process stream analysers shall be microprocessor based and their sample handling system shall be designed and fabricated by the analyser vendor only. The analyser vents and drain shall be routed to process or flare as applicable.

8.1.1.6 Enclosure: All the analyser shall be individually certified for area classification and required gas grouping. All electrical components of the analyser system and air conditioner shall be certified for use in IEC Zone-I area of required gas grouping,

8.1.1.7 Calibration gas cylinder/consumables

All calibration cylinders and other necessary items for analyser calibration shall be supplied by the contractor, considering the requirement of start up.z commissioning, Warranty period plus two years normal operation. The cylinders shall be located outside the’ shelter/cabinets and contractor shall provide suitable mounting accessories for the same. Cylinders shall be supplied in two sets, one shall be used and the other for storage and filling. Analysers like pH, Conductivity shall be two wire type and shall be installed outdoor.

8.1.2 Flue Gas Analysers

8.1.2.1 Flue gas monitoring system shall be used for continuous emission of stack and heaters. Typically SOx. NOx, O2, CO and CO2 analysers are required for stack and heater analysers.

O2 Analysers: Zirconia type (unless paramagnetic type required for process condition)
SO2/NO2/CO/ CO2: Dilution type for ~Ox and NOx and hot tap. extraction type for CO/C02 with principle to meet the required specification and performance unless otherwise specified in job specification.

8.1.2.2 Probe: Probe shall be provided with necessary filter and material suitable for the t temperature and process condition. The dilution shall take place near the probe where dilution type is specified.

8: 1.2.3 Sample tubing: Minimum S5 for dilution type. Teflon tube electrically heat traced and armoured for extraction type. Automatic temperature control shall be provided for the tubes.

8.1.2.4 Sample conditioning: Pressure reduction, heating/cooling flow meters etc along with other system components as per API and as recommended by vendor. Provision of first loop, condensate knock off shall be provided.

8.1.2.5 Analysers: Analysers shall be electronic microprocessor based with full diagnostic facility.

The analysers shall be located in prefabricated shelter.

8.1.2.6 Analyst shelter

i) The flue gas analysers shall be located in a prefabricated analyser shelter. Minimum width of the analyser shall be 3 m. The design and construction of the shelter shall be self supporting type and it shall be capable of housing required analysers, sample handling system and other accessories. All the air conditioner, all electrical component shall 'be certified flame proof Ex'd' of required gas grouping.

ii) The structure of shelter shall be constructed by suitable size ISMC (150/125)/ISMB(100) welded properly and adequately sized to ensure structural rigidity and to prevent
deformation during loading / unloading of the shelter. The floor shall be constructed from anti slip sheet plates strong enough to withstand load of all the equipments and atleast three maintenance personnel.

iii) External side walls and internal side walls shall be adequately strong and galvanized sheet of thickness 18 gauge with 45 mm x 60 mm x 45 mm x 3 mm thick MS U profile.

iv) The shelter roof shall be adequately strong and sealed to prevent entry of rain and jet water.

v) The shelter shall be provided with main door an emergency door opposite to main door. Both doors shall be opening outwards, provided with safety glass window and automatic spring door closer.

vi) Extension roof provided along the two longer sides shall be hanged at least 1000 mm outside the analyser shelter.

vii) The tag numbers of analysers shall be fixed near the main door. The tag number of each analyser shall be fixed near the respective items. Inlet/outlet pipes, electrical wires inside the junction box and cables shall be identified.

viii) Provision shall be made for keeping all the fast loop devices outside the shelter.

ix) Shelter shall have inside temperature of 24 0 C ±1- 2% with humidity less than 50% to obtain repeatability and reliability of the analysers.

x) Each shelter shall be provided with two no. LEL detectors.

8.1.2.7 Auto and span control: Contractor shall provide all hardware 'and software required for auto' zero and span calibration.

8.1.2.8 Calibration Gas Cylinder/Consumables

All calibration cylinders and other necessary items for analyser calibration shall be supplied by the contractor, considering the requirement of start up / c ommisioning warranty period plus two years normal operation. The cylinders shall be located outside the cabinets and contractor shall provide suitable mounting accessories for the, same; Cylinders shall be supplied in two sets, one shall be used and the other for storage and filling. Flue gas analysers fur emission monitoring (i.e sax. NOx, CO, COx, O2 ) shall meet the requirements of EPA, USA regulations.

9.0 Gas Detection System

9.1 LEL Detectors

Electrochemical type catalytic combustion type as specified' in job specifications. Material of construction shall be SS304. Accuracy shall be +/- 2%URY. LEL detectors shall be 3 wire type. Detectors shall be weather proof to 'IP 55 and flameproof Ex'd' suitable for indicated area classification. Necessary rain guard and dust shield shall be provided. Cable distance limitation between LEL detectors and control room 'shall be reviewed for' various vendors based on detectors voltage drop and current consumption. 'Necessary Calibration kit with gases for minimum 2 years operation after warranty period shall be provided. Portable LEL gas detectors (1 no.) shall be provided Separate gases shall be provided for warranty period.
The LEL monitors shall be installed on a panel to be installed in control room. LEL group alarms shall be provided in DCS.

9.2 \( \text{H}_2\text{S} \) Detectors

\( \text{H}_2\text{S} \) detectors shall be electrochemical type. Material of construction shall be SS304. Accuracy shall be +/- 3% URV. \( \text{H}_2\text{S} \) detectors shall be 3 wire type. Detectors shall be weather proof to IP 55 and flame proof Ex'd' suitable for indicated area classification. Necessary rain guard and dust shield shall be provided. Cable distance limitation between \( \text{H}_2\text{S} \) detectors and control room shall be reviewed for various vendors based on voltage drop and current consumption of detectors. Necessary calibration kit with gases for minimum 2 years operation after warranty period shall be provided.

Separate gases shall be provided for warranty period. Portable \( \text{H}_2\text{S} \) detectors (1 no.) shall be provided. The \( \text{H}_2\text{S} \) detector system shall be installed on a panel to be installed in control room. \( \text{H}_2\text{S} \) group alarms shall be provided in DCS.

10.0 Material Selection Guide Line

The material requirement of instrumentation item shall be governed by service conditions and process requirement. In general, Piping Material Specification (PMS) shall be used as a guide line of selection of material of instrumentation which shall include material its composition and other requirements. It is selector's responsibility to select the material which is suitable for pressure, temperature corrosion, erosion etc. For the instrument connected directly in line or through impulse line shall directly be governed by the respective piping class whereas for instrument mounted on equipment, 'vessel,' calms, reactors, etc, equivalent piping class shall be derived based on the lines connected to the respective equipment, vessel, column, reactor, etc, nozzle flange rating. In general, the following shall be considered as guidelines:

i) For all instruments in sour service, all materials of construction shall meet the requirements specified in NACE MR 01-75 latest editions. In addition, any other requirements if specified in respective piping class shall also be complied.

ii) Impulse pipe material shall be as per the corresponding piping class. However, for impulse tubing, material shall be SS 316, as aminimum. Better material shall be selected wherever required as per PMS and if SS 316 is not suitable.

iii) Valve body material of PMS to be considered for body material of control valve, self actuated pressure, control valve, field instrument, body bonnet of pressure relief valve, cage / chamber of all level instrument, chamber of senior orifice assembly and body of all other instruments.

iv) Trim material of valves as per PMS shall be considered. for the wetted parts of all instruments apart from body / bonnet / cage / chamber: and flange shall be as per trim material.

For piping class A1A, A6A, A8A, AIGA, A14A, A19A, B1A, B6A, B9A, B13A, DIA, EIA, FIA, A5A, B5A, D5A, A3A, A1A, B2A and D2A, S8 316 shall be used as trim material instead of trim material specified in the PMS. However stellitizing shall be provided " in steam cases and where dictated by specification. For piping classes A4F, A3F, B4F, A4G, B4G and D4G, monel shall be used for field transmitters, pressure / differential pressure gauges for body / socket / sensor / diaphragm upto the maximum specified temperature of 200°C. All flanges shall be as per PMS. The torque tube material of displacer instrument shall be inconel as minimum.

11.0 Inspection and testing requirement
11.1 Requirements of non destructive testing like, radiography, magnetic particle test, hardness test, hydrotest for items such as control valves, safety valves, orifice flange assembly, level gauges etc., shall be carried out strictly as per respective piping class.

For all instruments, welding and testing shall be carried out as per piping specifications.

Post weld heat treatment shall be carried out for all weldings of instrument as required in accordance with the requirements of piping material specifications.

11.2 For items use control valves, shutdown valves, pressure refer valves specification etc. radiography procedure and area of casting to be radiographed shall be as per ANSI B16.34 and acceptance criteria shall be as per ANSI B16.34 Annexure B, in general. However areas of casting to be radiographed for type of valves/desuperheaters not covered in ANSI B16.34 shall be in line with ANSI B16.34.

100 % radiography shall be done on the following areas of each item requiring radiography:

- inlet flange neck
- outlet flange neck
- cast nozzle (in case of safety, valves)
- all weld joints

Two shots shall be taken for each area to be radiographed, as a minimum.

11.3 Following test shall be carried out by contractor at his vendor's works and test certificate shall be furnished.

i) Material test certificate including NACE requirements for all instruments.

ii)* Calibration/ test certificates for all* instruments including control valves, safety valves.

iii)* Seat leakage test for control valves and safety valves.

iv)* Helium leakage test .for control valves and pressure relief :valves in H2, service.

v)* Test certificate for' safety valve set pressure and reseat pressure:

vi)* Hydrotest certificate for all inline instruments, pipes, tubes, fittings etc.

vii)* Radiography of control valve and pressure relief valves of rating ANSI 600# or above.

viii) Conformity certificate from sub-vendor.

ix) Capacity certificate duly approved by third party.

x) NACE compliance certificate.

All tests prefixed by (*) shall be witnessed by owner/owner representative /third party

The above is minimum requirement. Inspection agency engaged for the job shall detail out inspection and detailed testing procedure for individual items after contract is awarded.
11.4 Functional and simulation tests for all instruments supplied by the contractor shall be carried out at sub-vendor's works and witnessed by Purchaser/purchaser's representative's representative.

11.5 Refer to the standard specification 1071 6-52 0055 for inspection and testing requirements of DCS and PLC.

11.6 CCTV System

i) All material/equipment / integrated system shall be tested at the manufacturers workshop and witnessed by PDIL, and / or owner's representative prior to shipment of materials. A prefactory acceptance test shall be carried out prior to the system is available for testing in presence of PDIL, and / or owner's representative.

ii) After installation completion, field test shall be performed and control function shall be programmed in accordance with the functional requirements. Tests shall include functional tests of all input, output and alarm functions.

11.7 Analyser System

Each component and the system shall be tested separately at the vendor's works and the test certificates like material test certificate for all wetted parts and certificates from statutory bodies for use in area classification indicated in data sheet to be provided to /owner. After installation of the analyser system at site, demonstration of the tests carried out at vendor's works shall be explained to EIL./owner.

11.8 Specialty Service

Contractor shall engage specialty services from the sub-suppliers for special instruments and systems. This shall include engagement of qualified engineers and technicians from suppliers for following items for engineering, installation, field testing and commissioning

- all type of analysers
- all type of compressor instrumentation
- DCS/PLC
- CCTV
- Machine Monitoring System
- FGS

12.0 Installation Materials

12.1 Contractor shall ensure and supply all erection hardware required for the installation of complete instrumentation which form a part of the package unit. This includes items like cables, cable glands, junction boxes, instrument valves and manifolds, mounting accessories, impulse piping/tubing, pipe/tube fittings, pneumatic signal tubes, air line pipes and fittings, filter regulators, steam/electrical tracing, insulation materials, cable duct and trays, conduits, identification tags, structural material required for instrument supports and trays etc.
12.2 Clause 12.1 above broadly covers the items required for any typical plant, however the contractor shall supply all necessary items to make the installation and commissioning work complete in all respects, irrespective of whether these have been explicitly included in their scope or not.

12.3 Salient features and minimum requirements for some of the main installation materials is being described in the following paragraphs. For items for which no specification have been provided, vendor may follow their own specifications and prevailing international standards.

12.4 Cables

12.4.1 All cables shall have PVC insulated primary insulation of 85°C PVC as per IS-583(Type C/IEC 502). Inner and outer jacket shall be made of extruded flame retardant 90 ac PVC to IS-5831 Type ST-2 I mc 502. Oxygen index of PVC shall be over 30% and temperature index shall be over 250°C.

12.4.2 All cables shall be fire retardant as per standard IEC 332-3 Part 3 Cat. A. Fire resistance cables whenever specified shall be as per me 331 Cat. A.

12.4.3 The insulation grade shall be 600 V /1000 V as a minimum arid shall meet insulation resistance, voltage and spark test requirements as per BS-5308 Part-2.

12.4.4 All cables shall be armoured. Armour over inner jacket shall be of galvanised steel wire/flat as per IS-1554 part I / IEC 502. All the cores of single pair or multi-pair shall be twisted and numbers of twist shall not be less than 10 per metre.

12.4.5 For signal and control cables, inner jacket colour shall be black. Outer jacket colour shall be light blue, for intrinsically safe application and black for others. -For thermocouple extension cables the inner and outer jacket colour shall be as per IS-8784.

12.4.6 Maximum DC resistance of the conductor of the completed cable shall not exceed the following:

   a)  12.3 Ω/km at 20°C for cables with 1.5 mm² conductor.
   b)  39.7 Ω/km at 20°C for cables ‘with 0.5 mm² conductor.

12.4.7 The mutual capacitance of the pair or’ adjacent cores shall not exceed 250 pF/m at a frequency of 1kHz. The capacitance between any core and screen shall not exceed 400 µF/m at a frequency of 1 kHz.

12.4.8 L/R ratio of adjacent cores shall not exceed 40 µH / 0 for cables with 1.5 mm² conductor and .25 mH / 0 for cables with 0.5 mm² conductor.

12.4.9 The drain wire resistance including shield shall not exceed 30 Ω/km. Electrostatic noise rejection ‘ratio shall be over 76 dB.

12.4.10 A pair of communication wire shall be provided for multipair/multi triad cables », Each wire shall be 0.5 mm² of plain annealed single or multi-strand copper conductor with 0.4 mm thick 85°C PVC insulation. Insulation shall be green and red colour coded.

12.4.11 Contractor shall ensure a minimum of 20% of quantity of each type of cables supplied as spare including any special cable. ~d in each multipair cables 20% pairs shall be kept as spare.
12.4.12 Running length of the cable shall be printed at least at every 5 metre interval. For multipair/multitriad cables, a pair identification shall be provided with numbers at interval of pot more than 250mm as per vendor's standard.

12.4.13 Signal Cables

a) Single pair shielded signal/alarm cables shall be used between field instruments switches and junction boxes/local control panels.

b) Multipair individually and overall shielded signal/alarm cables shall be used between junction boxes/local control panels and control room / satellite rack room as the case, in general.

c) The single pair/triad cables shall be 1.5 m ms conductor size made of annealed electrolytic copper conductor of 7 strands with each strand of 0.53 mm diameter. Multipair cables with 0.5 mms conductor size shall have 7 strands of annealed electrolytic grade copper conductor with each strand of 0.3 mm diameter. Multi triad cable or multi pair cable with 1.5 mm² conductor shall have 7 strand with each strand of 0.53 mm diameter. Colour of core insulation shall be black blue in pair and black, blue and brown in a triad.

d) Shield shall be aluminium backed mylar/polyester tape bonded together with the metallic side down helically applied with either side having 25% overlap and 100% coverage. The minimum shield thickness shall be 0.05 m m in case of single pair/triad and 0.075 nun in case of multipair/triad cable.

e) Drain wire shall be provided for individual pair and overall shield which shall be 0.5mm² multi stranded bare tinned annealed copper conductor. The drain wire shall be in continuous contact with aluminium side of the shield.

f) All multi pair cables shall have 6 pair/12 pairs only while multitriad cable shall have 6 triads/8 triads only.

12.4.14 Control Cables

a) Single pair control cables shall be used between field mounted solenoid valves and junction boxes/local control panels and shall meet the requirements specified in para 12.4.13 above.

b) Multipair control cables shall be used between junction boxes /local control panel and control room mounted devices in general. These cables shall have only overall shielding.

c) These control cables shall have 1.5 mms conductor size with 7 stranded conductors of annealed electrolytic grade copper, with each strand of 0.53 nun diameter as minimum.

12.4.15 Thermocouple Extension Cables

a) Single pair shielded thermocouple extension cables shall be used between thermocouple head and junction boxes transmitters/local control panel mounted instruments.

b) Multipair individually and overall shielded thermocouple extension cables shall be used between junction boxes and control room mounted devices.

c) The type of thermocouple extension cables shall-be compatible with thermocouple used. In addition the colour coding of the primary insulation shall be as per IEC 60584-3.

d) The cable shall have 16 AWG and 20 AWG solid conductors for single and multipairs respectively.
e) All thermocouple extension cable shall be matched and calibrated in accordance with IEC-584-2.

t) Shield shall be aluminium backed by mylar/polyester tape bonded together helically applied with the metallic side down with either side having 25% overlap and 100% coverage. Minimum shield thickness shall be 0.05 mm for single pair and 0.075 mm for multipair cable. Drain wire shall be 0.5 mm2 multistrand bar-tinned annealed copper conductor. The drain wire shall be in continuos contact with the aluminium side of the shield.

g) Core inductance, shall not exceed 4. mH/km. However for I-type thermocouple inductance could be 8 mH/km.

h) All multi-pair cables shall have 6 pairs/12 pairs only.

i) For units with Gr.II C hazardous area classification of gas grouping polyethylene insulated cables with 70°C Polyethylene (FE) as 'per IS 64.74 or equivalent international standard shall be used in general with all other specification same as (a) to (h).

12.4.16 Power Supply And Other Cables

a) All power supply cables shall be as per IS-1554 Part I and shall have copper/aluminium conductors depending on conductor size. Minimum conductor size shall be 2.5 mm2 of copper conductor. For higher sizes, aluminium conductor can be considered. All these cables shall be PVC insulated and armoured.

b) Any other special cable required for instruments shall also be supplied as per requirements. Vendor shall ensure that these cables are armoured type and shall meet all other requirements specified in para 12.4.1 through 12.4.12, as applicable.

c) Refer electrical sec. specification for details.

12.5 Cable Glands

a) Contractor shall supply all cable glands required for glancing the above mentioned cables both at field instrument and local control panel side, junction boxes side and at control room side.

b) All cables glands shall be of nickel-plated brass and they shall be double compression type suitable for armoured cables.

c) Flame proof glands wherever required 'shall be supplied with EX'~ certification.

d) Vendor shall supply a minimum of 20% of cable glands as spare.

e) All cable glands shall be weather proof to IP-55.

f) Cable glands shall be NPT for all field items and junction boxes where as ET thread - with 'check nuts for control room end.

12.6 Junction Boxes

a) Contractor shall supply junction boxes as per the cables selected, wherever required. These shall be of die cast aluminium alloy (LM-6) body and shall be weather proof to- IP 55, as a minimum.
b) These boxes shall have terminals suitable for minimum or 4 mm" or less cable termination mounted on rails. 20% spare terminals shall be supplied in each junction box.

c) Telephone sockets and plugs shall be provided "in junction boxes

d) Flame proof junction boxes wherever required shall be supplied with Ex'd' certification. All such boxes shall be weatherproof to IF 55 also

e) Each junction box shall have a minimum of 2 Nos. for 6P/12C and 4 numbers for 12P124C spare entries. All spare entries shall be provided with plugs certified Ex'd' for flameproof junction boxes.

12.7 Instrument Valves and Manifolds

a) Contractor shall supply instrument valves (miniature type) and valve manifolds wherever required.

b) Body rating shall be as per piping class or better. All valves and manifolds shall be forged type only.

c) Valve body and trim material shall be SS 316 unless otherwise specified. Superior trim material shall be selected as requirement by process conditions. Packing material in general shall be of PTFE

d) For instrument air isolation valves, body material shall be nickel or cadmium paired carbon steel.

e) Vendor shall supply a minimum of 20% instrument valves and manifolds as spare.

12.8 Impulse Piping / Tubing

12.8.1 Tubing

a) Contractor shall supply 1/211OD x 0.049" thick ASTM A 269 TP 316 stainless steel fully annealed, cold drawn and seamless tubes as a minimum for impulse lines upto 600 # class. Higher thickness according to pressure rating shall be considered for higher pipe classes.

b) Monel or any other tubing shall be 'used where 5S316 is not suitable for the service.

c) The hardness of SS tubes shall be Rockwell RB 70-79

d) Steam tracing shall be 10 mm OD soft annealed copper tubes of electrolytic grade copper with wall thickness of 1 mm as per ASTM B 68M copper no. C 12200.

e) Instrument air distribution shall be with 6 nsn soft annealed copper, 1 mm thick PVC coated as per ASTM B 68M copper no. C 12200

f) Vendor shall supply a minimum of 20% of pipe/tubes as spare.

12.8.1 Piping

a) All piping shall be 1/2" NB with material and class as per piping class of the pipe on which the instrument is connected. The piping shall also be 3/4" NB, 11(2)" NB as the case may be. In case of vessel / equipment / reactor piping shall be corresponding equivalent piping class.
12.8.2 Pipes and Tube Fittings

12.9.1 Tube Fittings

a) Contractor shall supply flareless compression type of tube fitting and of three piece construction with design similar to Swagelok/Parker Hannifen/Ermeto etc.

b) The fitting/ferrule hardness shall be in the range of R.B’ 85-90.80 as to ensure a minimum hardness difference of 5 to 10 between tube and fittings. The ferrule shall be of stainless steel material, in general

c) Socket-weld type forged pipe fittings of suitable material and rating shall be supplied for pipe fittings. The minimum rating shall be 3000#. Weld neck fittings shall be used where socket weld type are not allowed by piping class.

d) Instrument air brass fittings shall be suitable for use on copper tubes conforming to ASTM B 68/B 68 M hardness not exceeding RB 50. All fitting parts shall be manufactured from Brass as per IS-319 bar stock or equivalent and shall be nickel

e) All threaded fittings shall have NPT threads as per ANSI/ASME B16.11 only

f) Vendor shall supply a minimum of 20% of each type of pipe/tube fittings as spare.

12.9.2 Pipe Fittings

All pipe fittings shall be according to piping material specification as per piping class of the pipe on which instrument is connected. In case of vessel/equipment / reactor, PMS of equivalent piping class shall be considered.

12.10 Pneumatic Signal Tubes

a) Contractor shall supply 6 mm OD x 1 nun thick PVC covered fully annealed electrolytic grade copper tubes as per ASTM B68.74A Cu. No.122 (DR) for pneumatic signal tubes.

b) Contractor shall avoid use of intermediate connections and shall estimate single length for each instrument location.

c) Contractor shall supply a minimum of 20% length of these tubes as spares.

12.11 Instrument Air Lines Fittings and Valves

a) Seamless galvanised, inside and outside, carbon steel pipes used for instrument air distribution shall be as per IS 1239 J3A pipe class.

b) Galvanised forged screwed carbon steel screwed fittings of 2000# rating fittings shall be used.

c) Isolation valves on instrument air service shall be packless gland type full bore ball valves.

d) Vendor shall supply a minimum of 20% of air pipe, fittings and valves as spare.

12.12 Air Filter Regulators

a) Instrument air filter regulator of suitable size, range and capacity shall be supplied for each pneumatic instrument.
b) The body of the filter shall be anodised aluminium.

c) The filter shall have 25 μm sintered bronze/ceramic filter element as a minimum and shall be provided with manual drain and 211 nominal size pressure gauge. Other filter size shall be considered based on recommendation, of I/P transducer vendor.

d) Contractor shall supply a minimum of 20% of air filter regulators of each size and range as spare.

12.13 Cable Trays and Cable Ducts

a) All cables on the main and sub pipe rack shall be laid in cable, duct. Cable ducts shall be fabricated as per 'Duct Fabrication Details' standard No. 1071-7-52-0254.

b) All branch cables/tubes shall run on cable trays.

c) These cable trays shall be made out of M.S steel sheets of 2.5 mm thickness unless galvanised mild steel is specified. Ladder trays shall be of mild structural steel and shall be painted with red-oxide primer. 50mm x 50mm angle shall be used as a minimum.

d) The width shall be so selected that 50% of tray space is available for future use.

e) Suitable cable clamps shall be supplied for binding the cables/tubes at every 500 mm.

12.14 Instrument Support/Structural Steel

a) Contractor shall supply instrument stands, stancheons and other structural steel material required for supporting the cable trays, impulse lines and instruments.

13.0 Installation

13.1 Contractor shall be responsible for installation of all the items in their scope of supply including supply, fabrication and erection of all installation / erection material. The scope of installation shall include all field instruments and control systems like field instruments, analyser system, gas detector systems, control system equipments' L~ DCS, PLC, Hart maintenance' system in main control room /satellite rack room/local control room etc. local and remote panels including supply fabrication / erection / installation of all erection material i.e cables, cable glands, junction boxes, cable ducts, trays, conduits, instrument supports, trenches, instrument road crossing as required to complete the job in all respect.

13.2 Contractor's scope shall include installation of CCTV system, wherever required including cameras along with accessories and mounting pole, cabling and control room mounted items including supply and installation of all erection material.

13.3 Supply/ fabrication and installation of instrument mounting posts, support stands / frames, fittings, brackets and other consumables for mounting and supporting all instruments, instrument system components and fixing the same.

13.4 Whenever installation is beyond the scope of contractor, purchaser or its authorised representative shall install the instruments as per the drawing /document / details provided by the contractor. However, in such a case it must be ensured that complete installation materials shall be supplied.
13.5 Any panel or instrument which has been disconnected or removed for transportation shall be replaced or reconnected where necessary.

13.6 Installation of any underground cables shall include excavation, cable segregation, support, back filling with grades of sands, tiling, trench makers etc.' In case of underground cables are required to be in RCC trenches, all installation shall be carried out except excavation. Suitable cable markers made of aluminium shall be provided for all underground cabling.

13.7 Installation of above ground cables includes identification suitable supports, angle/perforated / ladder tray due fixing and fire proof (if required as per job specification).

13.8 Installation of cable tray/ ladder tray, ducts and miscellaneous support materials, clips as required for supporting aboveground instrument cable, tube etc.

13.9 Installation of suitable cable clamps / tray on multicore cables just before termination into the junction box or panel such that the weight of cables is not supported by the cable glands.

13.10 Mark off, gland and connect all instrument cables, supply and install markers / ferniles etc for cable identification in accordance with the specification.

13.11 All, instruments including direct mounted instruments like thermocouples, thermowells, temperature gauges, pressure’ gauges, pressure switches etc. ‘shall be installed in such a Way that they ‘have good readability and accessibility. Platforms and l adders shall be pr ovided to meet this requirement, if necessary.

13.12 The capillary of all capillary type instruments shall be supported properly and shall be protected against mechanical damage.

13.13 All pressure/differential pressure instruments shall be provided with block and bleed/bypass, drain/vent valves etc as per the installation standards, and shall have accessibility.

13.14 All primary piping/tubing (impulse lines) shall have a slope of 1 in 12 on the horizontal run.

13.15 All welding shall be carried out as per the relevant codes with proper electrodes. Any testing (non destructive) like D.P. test and radiography on root held ‘and final weld shall be carried out as per PMS. All consumables shall be part of contractor's scope of supply. Any pre/post weld treatment as required by the relevant codes and piping material specification shall be carried out. All non destructive tests shall be carried out as per piping material specification.

13.16 All threaded joints shall be joined by PTFE tapes only.

13.17 All impulse lines shall be supported at regular intervals.

13.18 Instrument drain/vent connections shall be piped to safe area like oily water sewer or above pipe racks to avoid accumulation of hazardous fluid in the plant atmosphere, For hydrogen and Lethal services like CO etc all vent / drains shall be’ connected to closed system even it is not shown in the P&IDs.

13.19 Steam tracing wherever required shall be carried out by 10 mm OD x 1 mm thick copper tubes and condensate traps shall be provided to collect all ‘the condensate and shall be piped to the nearest pipe drain funnels.
13.20 All tubes/cables shall be properly laid on cable trays which shall be supported at regular intervals.

13.21 Separate routing or physical separation and maintained between signal cables, shut down and power cables.

13.22 Wherever intrinsically safe system cabling is employed, the minimum separation of 150 mm shall be adhered between IS (intrinsically safe) and non IS signal cables.

13.23 The cases of instruments shall be earthed by earthing wire to the nearest earth bus bar for safety reasons.

13.24 Painting of cable trays/ducts, mild steel cable trays, angle trays, instrument supports and all structural supports shall be painted as under :-

   a) The surface to be painted shall be thoroughly cleaned with brush sand paper to remove all scales. After cleaning, one coat of red oxide zinc chromate primer shall be given conforming to IS-2074 and allowed to dry. One coat of final when paint shall be applied:

      Second and final coats of paint of final colour shall be given before handing over the plant/commissioning.

   b) Instrument impulse lines shall be painted as per painting requirements of main pipe and equivalent pipes in case of vessel / equivalent / reactor.

13.25 For the purpose of installation planning and scheduling shall be made on daily and entire installation period with other disciplines co-ordination shall be done with other EPCC contractors for common area of work.

13.26 Mounting of instrument / junction boxes shall be at a height of 1.3 metre from grade level / finish floor level.

13.27 Temperature extension of suitable length shall be provided in the impulse line of the instrument installation where process fluid temperature is higher than the maximum withstanding temperature of the instrument.

14.0 Impulse line requirements

14.1 All instrument impulse shall be provided with the following:

   i) Piping or tubing or combination of piping and tubing shall be as per requirement of job specification or licencor's requirements.

   ii) All instruments shall be provided with isolation, drain and/ or vent valves with vent/drain end duly capped. This isolation valve shall be in addition to the first isolation /root valve provided on the pipe or vessel at instrument take off.

   iii) For flow transmitters integral 3 valve manifold shall be provided.

   iv) For remote installation of instrument minimum one pair of break flanges shall be provided.
v) For impulse line with viscous / congealing services a tee off with blind flanged shall be provided for cleaning near to first isolation valve.

vi) For diaphragm seal type instruments, spacer ring with vent and drain connection along with vent / drain valve with end capped.

vii) For instrument flushing/purging line additionally check valve, rotameter, DP regulator, restriction orifice with isolation valves shall be provided.

viii) All the valves used for impulse line shall be globe type.

ix) Contractor to study all the installations and meters shall be provided above the tapping for all types of condensable vapour service.

x) Syphon shall be used for steam service.

xi) Extension in the impulse piping / tubing of suitable length may have to be provided for those instrument installations where process fluid temperature is higher than the maximum withstanding temperature of the instrument / diaphragm.

14.2 Piping standard shall be used for all installation where specified in job specification. For rating upto 600 #, the connection to the transmitters shall be with a male connector and tubing 1/2" OD. For rating higher than 600 #, no tubing shall be used. The connection to the transmitters shall be with 1/2" piping with flanges in between piping standard, all pipes shall be 1/2" NB unless higher sizes required to meet the requirements, with all fittings suitable for the piping. All the joints shall be welded or flanged as required. For instrument end connection i.e root valve of orifices and other items, level gauges vent and "drain connection, seal welding shall be provided. For non diaphragm seal instruments and instruments where provided with threaded connection, no welding is required at instrument end.

14.3 Tubing standard shall be used upto 600 # only where the same is required as per job specification. For rating above 600 # and hydrogen/lethal service, only piping standard shall be used. The tubing shall be 1/2" OD tube with all fittings suitable for the same. Valves used shall be threaded. At the first isolation / root valve end suitable pipe tag to tubing conversion fittings shall be used. For remote installation suitable unions / couplings shall be used.

14.4 Based on above guideline, contractor shall prepare, develop installation standards and indicate bill of material for each installation.

14.5 Steam, tracing of all instruments shall be considered on steam traced Process lines as per P&ID and other documents. For steam tracing of instruments copper tube & brass fittings shall be used, Tube fittings shall be double ferrule type. For each instruments steam trace bore shall be provided with steam trap duly connected to plant.

14.6 Use of standpipe for level instruments shall be as per job specification. The representation on the P&IDs for level instrument connections is somatic only.

14.7 Standpipe shall always be taken from the side.

14.8 Installation of Systems (DCS, PLC, Analysers etc.)

14.8.1 The system shall be installed by the system vendor who would be responsible for installation and termination of interconnecting cables in the system racks / cabinets. Refer to standard specification of DCS 1071-6-52-0055 for detailed requirements. All interconnecting cables shall be identified and the
14.8.2 All system communication cables shall be layed in covered GI (galvenised iron) trays away from power cables. Prefabricated cables shall be avoided for interconnection if these are to be routed out side the cabinets. If unavoidable these should be layed in covered GI trays.

14.8.3 All panels/cabinets shall be properly levelled and secured firmly with the base supporting structure. However, the consoles and printer stands need not be secured to base structure.

14.8.4 Grounding

   a) Each cabinet, console and other equipment supplied as a part’ of system shall have earthing lugs which shall be secured to the AC mains earthing bus

   b) All circuit grounds, shields and drain wires shall be connected to the system ground' bus which is isolated from AC mains earth'. This bus shall typically be 25 mm wide and 6 mm thick of copper

   The total resistance of system ground shall be less than 5 0 unless otherwise recommended by system manufacturer.

   c) Safety barriers, if used, shall be secured to 'Safety ground' which shall have typically ground resistance of less than 1 Ω. The bus shall be designed considering a fault level of 0.5 A at 250 V r.m.s. per barrier.

14.8.5 All other installation guidelines as recommended by system manufacturer ~hall be followed.

15.0 SITE TESTING AND CALIBRATION

15.1 All impulse lines shall be tested hydrostatically at 1.5 times' the maximum operating pressure. Ensure that instrument and vessel/piping is isolated during this test.

15.2 In case of special instruments/items where hydrotesting is not permitted due to service conditions, the impulse lines testing shall be carried out by using air or nitrogen.

15.3 All external cage type level instruments shall be tested upto 1.5 times operating pressure by using nitrogen only.

15.4 After pressure testing, all these impulse lines shall be drained and dried with dry air to remove any traces of moisture, oil and dust.

15.5 Instrument air lines shall be duly tested for any leak after pressurising and isolating the main root valve by soap solution. After isolation, the rate of fall in pressure shall be less than 1 kPa for every 4.4 metre (1 psi for each 100 feet) of copper tubing for a test period of 2 minutes.

15.6 Pneumatic signal tubes shall be flushed and tested with instrument air for any leak at a pressure of 1.5 k g/cm²g. After pressurising the line, the source of pressure is cut off and rate of fall in pressure shall be less than 1 kPa for every 4.4 metre (1 psi for each 100 feet) of tubing for a period of 2 minutes.

15.7 All instrument cables shall be tested for continuity and insulation. While meggering the cables for insulation testing, ensure that all instruments and barriers are isolated at both ends.

15.8 All instruments supplied by the vendor shall be calibrated usingproper test equipment.
All instruments shall be calibrated for 0%, 25%, 50%, 75%, 100% and vice versa.

All temperature gauges shall be calibrated using temperature baths.

All thermocouple activated instruments shall be calibrated by generating millivolts by a potentiometer.

All transmitters shall be calibrated as per instrument ranges.

All displacer type level transmitters shall be calibrated with Water or suitable, fluids' and corrected for specific gravity.

All alarm and trip switches shall be calibrated over the entire range and finally set and checked for alarm/trip points and reset points as per the alarm/trip set point schedule. After setting, these shall be sealed.

All control valves, prior to stroke checking, shall be externally cleaned thoroughly. The full stroke of valve shall be checked for opening and closing. Any adjustment required for obtaining full stroke and reducing hysteresis shall be carried out. The hysteresis shall not be more than 1% URV (upper range value) with positioners and 5% DRV without positioners.

Bubble tight shut-off control valves and shut down valves shall be checked for seat leak test and gland leak test.

Solenoid valve shall be checked functionally for its operation.

Safety valves and relief valves shall be set/tested by using dry air/nitrogen. Leakage if any shall be removed by proper lapping of seat and disc.

All electronic/pneumatic receiver instruments shall be calibrated as per the manufacturer's instructions. Controllers shall be aligned properly.

All special instruments like analyzer shall be checked and calibrated as per manufacturer's instructions. Prior to testing, all analyzer’ sample lines shall be thoroughly cleaned by carbon tetra Chloride or any other cleaning liquid. Air cleaning, these lines shall be thoroughly purged with dry nitrogen.

No oil should be used in oxygen and chlorine service lines.

The accuracy of overall loop shall be. within ± 1% for electronic and ± 15% for pneumatic loops.

After performing the calibration of all instruments, the entire loop shall be checked for proper operation.

The entire shutdown scheme shall be simulated from the process trip switches and the scheme shall be tested for its proper operation prior to start up of the unit.

If no instrument air is available vendor shall provide necessary nitrogen cylinder~ to carry out the above activity.

Testing of Systems
15.26.1 All the system functions shall be checked thoroughly for proper functioning. These shall include but not limited to the following tests :-

a) Visual and mechanical.
b) Complete system configuration loading.

c) Demonstration of all system functions.
d) Checking of all systems displays.
e) Checking of correct functioning of all keyboards.
f) Demonstration of all system diagnostics.
g) Checking of proper functioning of all printers, hardcopy unit, and printing of reports.
h) Checking of all disc drives.
i) Complete checking of logic system, loading of user's program and checkout of results.
j) Checking of correct change-over of the back-up/redundant units in case of failure of main units.

15.26.2 The input signals shall be simulated by disconnecting the field wires for all inputs Wherever control room mounted Transmitters/Converters/Receiver switches are used, the functioning of same shall also be checked.

15.26.3 Requirements of para 15.26 shall be read ill conjunction with 1071-6-52:-005-5.

15.27 Loop Checking

15.27.1 Contractor is totally responsible for all work related to loop checking including cable laying, dressing, identification, ferruling, calibrations; loop testing in coordination with Control system vendor.

15.26.2 The procedure outlined in section 1.4 Part II of 1071-6-25-0055 (testing, installation, commissioning and acceptance of DCS system) shall be followed for loop checking. However the division of scope of work related to loop checking between various sub contractors shall be decided by contractor.

15.27.3 Before proceeding for loop checking the calibration results of individual elements shall be recorded on the contractor supplied proforma which shall be approved by I' owner for correctness of installation/ measurements and calibration results.

15.27.4 For calibration of special instruments and loop checking and for 'loop checking of sub vendor packages contractor shall do necessary coordination with sub supplied. The contractor shall carryout the necessary loop checking to the satisfaction of Purchaser/purchaser's representative which shall be part of contractor's scope of work.

a) For special instruments like analysers the contractor shall ensure the presence of supplier's, technical personnel during field testing/ loop checking and during commissioning to assist above-activities.
b) Loop testing for all control loops shall be generally by simulating process conditions for at least 0%, 25%, 50%, 75% & 100% full scale inputs. Detailed procedure shall be submitted to Purchaser/purchaser’s representative for approval before proceeding with loop checking.

c) In case of shut down systems, field/receiver switches are simulated for abnormality by disconnecting the wires at terminal points. Function of all associated systems are checked including performance of solenoid valves, on/off control shut down valves including proper functioning of limit switches and other accessories. Adjustments of limit switches wherever necessary also from part of checking of loop performance.

d) Performance of individual loops shall be accepted for an overall accuracy of + 1.0%. Where deviation is found to exist more than specified limit bidden shall re-calibrate the instruments which shall also form part of loop testing at no extra cost, time implications.

e) Contractor shall complete all the entries in the loop sheet related to field instrumentation as well as the control system side with acceptance of loops and hand over the sheets to / owner for final acceptance

16.0 COMMISSIONING

16.1 This activity shall be carried out in a systematic manner so as to avoid any accident to plant and operating personnel

16.2 During the plant start up all the instruments calibration, controller alignment, trip point settings shall be trimmed so as to meet the operation requirements

16.3 Prior to guarantee run of any unit, the vital instruments as/required by vendor have to be recalibrated and the results recorded.

16.4 As built drawings shall be prepared after installation and commissioning is over.

17.0 Training

Unless specified otherwise the following shall be provided by contractor for system training for owner.

Contractor shall arrange training for Owner's personnel. Different type of courses shall be offered for operation! process engineers and operators, instrument maintenance engineers and technician. Contractor shall indicate a detailed proposal for training in the offer. Travel and living expenses of the owner's personnel shall be borne by the Owner. Apart from the hardware and software maintenance training and site training as specified in 1071-6-52-0055, contractor shall also offer operation training basically meant for operating personnel. The various facilities available in the system for operation, actions required during emergencies and identifying the various diagnostic messages shall be main contents of the operation training.

Hardware and software maintenance training - At system vendor's work.

Operation Training - At system vendor's work

Site Training - Operation and maintenance

18.0 POST WARRANTY MAINTENANCE FOR SYSTEMS

Refer Document 1071-AMC-01.
The requirement of post warranty maintenance for all system oriented items shall be as follows:

a) In the event of any malfunction of the system hardware/ system software, experienced, service engineer shall be made available at site within 24 hours on the receipt of such information from owner.

b) The contract shall include detailed proposal related to supply of maintenance spares, tools and tackles as required, travel, boarding and lodging of service engineer to site on short notice.

c) EPCC contractor after completion of warranty shall transfer the contract of system vendor to owner for direct interaction between owner and system vendor.

d) The services under Post Warranty Maintenance Contract including supply of spare parts and services shall broadly encompass the following:

- **Preventive Maintenance**
  Once in a year, involving complete overhaul of the system, inspection of hardware and software, fault prediction, inspection of power supply quality, environmental and operating condition checks, calibration checks, major repairs/replacements and detailed reporting.

- **Periodic Maintenance**
  Site visits, minimum four-six times in a year, inspection of general healthiness of the system, study and advice on daily maintenance, inspection of hardware and software, if any problem is reported, running of test programmes, on-line servicing and solving reported problems. Checks shall be conducted on running system i.e (a) Online sub-systems, (b) Power supply checks, (c) C– (d) printer, (e) Any Other vendor recommended service. Complete scope of work involved under each category must be outlined by the system vendor.

- **Software maintenance**
  Maintain existing software to improve and utilise existing application and improve performance of the system. Minor modification of the software shall also be covered under this scope.

- **Emergency Service**
  Any failure shall be on system suppliers account The Engineer must report at site within 24 hours of report of failure; with necessary spares. The system must be brought back within 24 hours after reporting at site.

- **Software Updates**
  All future updates on the system hardware/software supplied shall be made available to the owner as and when available. The installation charges as applicable shall be included.

**19. LIST OF DOCUMENTS ATTACHED**

- Instrument Connections on Vessels & Tanks
- Instrument Connections on Piping
- Thermowell
STANDARD SPECIFICATION FOR
INSTRUMENTATION WORK

Thermocouple/ RTD assembly with thermowell
Orifice Plates and Flanges-Dimensional details
Duct Fabrication Details
AMC Requirements
Instrument Index Blank Format
STANDARD SPECIFICATION

FOR

INSTRUMENT TUBE FITTINGS
1.0 GENERAL

1.1 Scope

1.1.1 This standard specification, together with the data sheets attached herewith, covers the Requirements for the design, materials, inspection, testing and shipping of instrument tube fittings which includes the following types:

   a) Stainless steel compression fittings (for stainless steel tube)
   b) Brass compression fittings (for copper tube)

1.1.2 The related standards referred to herein and mentioned below shall be of the latest Editions prior to the date of the purchaser's enquiry:

   ANSI/ASME American National Standards Institute/American Society of Mechanical Engineers

   B 1.20.1 Pipe Threads General Purpose (Inch).

   B 16.11 Forged Steel Fittings - Socket Welding and Threaded.

   BS-4368 Carbon and Stainless Steel Compression Couplings for Tubes.

   EN 10204 Inspection Documents For Metallic Products.

   IS-319 Specification for free cutting Brass Bars, Rods and Sections.

   ISA Instrumentation, Systems and Automation Society.

   RP 42.1 Nomenclature for Instrument Tube Fittings.

1.1.3 In the event of any conflict between this standard specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

   a) Statutory Regulations

   b) Data Sheets

   c) Standard Specification

   d) Codes and Standards

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to the vendor attached along with the material requisition.

1.2.2 Whenever a detailed technical offer IS required, vendor's quotation shall include the Following:
a) Compliance to the specifications.

b) Whenever specifically indicated, detailed specification sheet for each item, which shall provide the information regarding type, size, material of construction etc. of the items. The material specifications and units of measurement for various items in vendor's specification sheets shall be to the same standard as those indicated in purchaser's data sheet.

c) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason to deviate, they must include a list of deviations item wise summing up all the deviation from the purchaser's data sheets and other technical specification along with technical reasons for each of these deviations.

d) Catalogues giving detailed technical specifications, model decoding details and other information for each type of instrument tube fitting covered in the bid.

1.2.3 All documentation submitted by vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals etc., shall be in English language only.

2.0 DESIGN AND CONSTRUCTION

2.1 Stainless Steel Tube Fittings

2.1.1 Nomenclature of all tube fittings shall be as per ISA RP 42.1.

2.1.2 Fittings shall be of flare less compression type having four-piece (for double compression type) construction consisting of two ferrules, nut and body or three piece (compression type construction consisting of single ferrule, nut and body suitable for use on tubes of specified material for example stainless steel tubes conforming to ASTM A269 TP 316L with hardness in the range of HRB 70 to 79.

2.1.3 All parts of the tube fittings shall be of 316 Stainless Steel unless specified otherwise.

2.1.4 Hardness of the ferrules shall be in the range of HRB 85-90 so as to ensure a hardness difference of the order of 5 to 10 between tube and fittings for better sealing.

2.1.5 Nuts and ferrules of a particular size shall be interchangeable for each type.

2.1.6 Spanner hold shall be metric.

2.1.7 Threaded ends of fittings shall be NPT as per ANSI B 1.20.1.

2.1.8 Specific techniques like silver plating shall be used over threading in order to avoid jamming and galling.

2.1.9 Ferrule finish and fitting finish shall be such that there is no abrasion/galling when the nut
is tightened.

2.1.10 All instrument tube fittings in oxygen and chlorine service shall be thoroughly degreased using reagents like trichloro-ethylene or carbon tetrachloride. End connection shall be plugged after degreasing process in order to avoid entrance of grease or oil particles.

2.2 Copper Tube Fittings

2.2.1 Nomenclature of all tube fittings shall be as per ISA RP 42.1. Fittings shall be of flare less compression type and of three-piece construction consisting of ferrule, nut and body Suitable for use on copper tubes conforming to ASTM B68 1B68M, hardness not exceeding HRB 50.

2.2.3 All parts shall be manufactured from brass as per IS 319 bar stock and nickel plated.

2.2.4 For better grip, vendor shall maintain hardness difference between tube and ferrule and indicate the same along with the offer.

2.2.5 Threaded ends of fittings shall be NPT as per ANSI B 1.20.1.

2.2.6 Spanner hold shall be metric.

3.0 NAMEPLATE

3.1 No separate nameplates are required on the fittings. However, manufacturer's name/trademark should be punched on a visible place on the body of each fitting for easy identification.

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all items at vendor's works, inline with the inspection test plan for instrument tube fittings.

4.2 Vendor shall submit following test certificates and test reports for purchaser's review:

4.2.1 Type test reports for following tests in accordance with BS-4368 Part IV:

   a) Hydrostatic proof pressure test.
   b) Minimum hydrostatic burst pressure test.
   c) Disassembly and reassembly test.
   d) Minimum static gas pressure (vacuum) test.
   e) Maximum static gas pressure test.
   f) Hydraulic impulse and vibration test.

4.2.2 Material test certificates as per clause 3.1 B of EN 10204.

4.2.3 Routine test reports for following tests:

  a) Hydrostatic Test

     Instrument tube fittings shall be hydrostatically tested at ambient temperature at test pressures given in Annexure I of this specification. During and after the hydrostatic test, the tube fittings shall not show any leakage or rupture.
b) Pneumatic pressure test: The fittings shall be tested at 7 kg/c mg of dry air. There shall not be any visible leakage when immersed in water or coated with a leak detection solution.

c) Disassembly and reassembly test.

d) Hardness verification:
   Hardness test shall be carried out on each rod used for machining ferrules. Vendor shall ensure that after machining, the finished ferrules shall meet the required hardness given in the specification.

d) Dimensional test report

4.3 Witness Inspection

4.3.1 All fittings shall be offered for pre-dispatch inspection for the following as a minimum:

   a) Physical dimensional verification and workmanship on representative samples.
   b) Hydrostatic and pneumatic tests as per clause 4.2.3 of this specification on representative samples.
   c) Hardness verification as per clause 4.2.3 of this specification.
   d) Disassembly and reassembly test on representative samples.
   e) Review of all certificates and test reports as indicated in clause 4.2 of this specification.

4.3.2 In the event when no witness inspection is carried out by purchaser, vendor shall any way complete the tests and test reports for the same shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 All threads/ends shall be protected with plastic caps to prevent damage/entry of foreign matter.

5.2 All the fittings in oxygen and chlorine service shall be separately packed along with a certificate indicating ‘SUITABLE FOR OXYGEN/CHLORINE SERVICE’, as applicable.

6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents, which are specifically indicated in the material requisition.

6.2 Any offer not conforming to the above requirements, shall be summarily rejected.
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Size of Tube Fittings</th>
<th>Material</th>
<th>Line Pressure No. Class</th>
<th>Hydrostatic Test Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6mm and ½”</td>
<td>Stainless steel</td>
<td>&lt;600#</td>
<td>153 Kg/cm² g</td>
</tr>
<tr>
<td>2</td>
<td>6mm and ½”</td>
<td>Stainless steel</td>
<td>&gt;=900# to &lt;=1500#</td>
<td>383 Kg/cm² g</td>
</tr>
<tr>
<td>3</td>
<td>¼” and 3/8”</td>
<td>Brass</td>
<td></td>
<td>80 Kg/cm² g</td>
</tr>
</tbody>
</table>
STANDARD SPECIFICATION

FOR

INSTRUMENT TUBING
ABBREVATIONS:

<table>
<thead>
<tr>
<th>ID</th>
<th>Inner Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD</td>
<td>Outer Diameter</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
</tr>
</tbody>
</table>
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ANNEXURE S:

ANNEXURE - 1: MAXIMUM WORKING PRESSURE AND HYDROSTATIC TEST PRESSURES FOR INSTRUMENT TUBING
1.0 GENERAL

1.1 Scope

1.1.1 This standard specification, together with the data sheets attached herewith, covers the requirements for the design, materials, inspection, testing and shipping of Instrument Tubing which includes the following types:

a) Stainless steel tubes
b) Copper tubes

1.1.2 The related standards referred to herein and mentioned below shall be of the latest edition prior to the date of purchaser's enquiry;

ASTM


B 251 Specification for general requirements for wrought seamless copper and copper alloy tube.

B 251M Specification for general requirements for wrought seamless copper and copper alloy tube (Metric)

B 68 Specification for seamless copper tube, bright annealed.

B 68 M Specification for seamless copper tube, bright annealed. (Metric)

E 243 Standard Practice for Electromagnetic (Eddy - Current) Examination of Copper and Copper - Alloy Tubes

EN 10204 Inspection Documents for Metallic Products

1.1.3 In the event of any conflict between this standard specification, job specification/data sheets, statutory regulations, related standards, codes etc. the following order of priority shall govern:

a) Statutory regulations
b) Job specification
c) Standard specification
d) Codes and standards

1.2 Bids
1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition.

1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:

   a) Compliance to the specifications.

   b) Whenever the requirement of a detailed specification sheet, is specifically indicated, the specification sheet shall provide information regarding size, length, construction, materials etc. of the Item s. The material specifications and units of measurement for various items in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheet.

   c) Overall dimensions in mm/inch as per purchaser's specification.

   d) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason to deviate, the must include a list of deviations item wise. Summing up all the deviations from the purchaser's data sheet and other technical specification along with the technical reasons for each of these deviations.

   e) Catalogues giving detailed technical specifications; model decoding details and other related information for each item covered in the bid,

1.2.3 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation and maintenance manuals shall be in English language only.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of reproducible, prints and soft copies shall be dispatched to the address mentioned adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data by the vendor or after placement of purchase order shall include the following as a minimum;

   a) Specification sheet for each type of tube.

   b) Copy of test certificates of all tests indicated in clause 4.0 of this specification.

2.0 DESIGN AND CONSTRUCTION

2.1 Stainless Steel Tubes

2.1.1 The tubes shall be 316L Stainless Steel fully annealed, seamless and cold drawn as per ASTM A 269.

2.1.2 The hardness of the tubes shall be limited to HRB 70-79. Equivalent hardness as Rockwell superficial scale (30T/15T) or Vicker's hardness scale shall also be acceptable.

2.1.3 Tubes shall have good surface finish and shall be free from scratches burrs etc. and
suitable for bending.

2.1.4 Maximum working pressure shall be as per Annexure - I attached with this specification.

2.1.5 Tubes shall preferably be supplied in length of 5 to 6 metres without welding in between. Tube length less than 5 meters shall be rejected.

2.1.6 All tubes in oxygen and chlorine service shall be thoroughly degreased using reagents like trichloro-ethylene or carbon tetrachloride and tube ends shall be plugged after degreasing process in order to avoid entrance of grease or oil particles.

2.2 Copper Tubes

2.2.1 Copper Tubes (PVC Jacketed)

a) The tube shall be soft annealed copper with 6mm OD and a wall thickness of 1.0mm as per ASTM B 68M copper No. C 12200.

b) The tube shall be jacketed with black PVC. The jacket thickness shall be 1.6mm. The PVC jacket shall confirm to ASTM D-1047.

c) The tube ends shall be plugged prior to transportation.

d) The tube shall be continuous length without any brazing in between.

e) The length of single tube shall preferably be100 metres. However any tube length less than 70 meters shall be rejected unless specifically required otherwise in job specification.

f) The dimensional tolerances shall be as per ASTM B 251M.

2.2.2 Bare Copper Tubes (For Steam Tracing)

a) The tube shall be soft annealed copper with 3/8" (10mm) OD with wall thickness of 0.049" or 6mm OD with wall thickness of 1.0mm as per ASTM B6&.copper No.C12200.

b) The tube ends shall be plugged prior to transportation.

c) The tube shall be continuous length without any brazing in between.

d) The length of single tube shall preferably be 100 metres. However any tube length less than 70 meters shall be rejected unless specifically required otherwise in job specification.

e) The dimensional tolerances shall be as per ASTM B 251.

f) Maximum working pressure shall be 53.0 kg/cm²g at 38°C unless specified otherwise.

3.0 NAME PLATE

3.1 The following information shall he marked on the stainless steel tubes:
a) Name of manufacturer
b) Type and material grade of tube
c) Tube outer diameter and wall thickness.

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at vendor's works, in line with the inspection test plan for instrument tubing.

4.2 Vendor shall submit following test certificates and test reports for purchasers review:

a) Material test certificates as per clause 3.1B of EN 10204.

b) Hydrostatic test for stainless steel tube and bare copper tubes as per clause 4.3 of this specification.

c) Pneumatic test for PVC jacketed copper tubes as per clause 4.4 of this specification.

d) Hardness / tension test for stainless steel tubes as per clause 4.5 of this specification.

e) Ball test for copper tubes as per clause 4.6 of this specification.

f) Eddy current examination of copper tubes as per ASTM E-243

g) Dimensional test report.

4.3 Hydrostatic test

4.3.1 Stainless steel and bare copper tube shall be hydrostatically tested at ambient temperature at test pressures given in Annexure - 1 attached with this specification. During and after the hydraulic test, the tubes shall not show any leaks or rupture.

4.4 Pneumatic test

PVC jacketed copper tubes shall be tested at 7.0 kg/cm² of dry air. During and after the test, tubes shall not show any leak or rupture.

4.5 Hardness/Tension Test

All mother tubes shall be hardness tested for each heat prior to drawing for proper quality control. The hardness of the drawn tubes shall be checked by Rockwell Hardness Test. Following shall apply;

a) For tubing less than 0.6Sin (1.6Smm) in wall thickness, Rockwell superficial hardness test on 30T / 1ST scale or Vicker's scale shall be equivalent to HRB 70 - 79.

b) Hardness test is not required for tubes smal1er than 1/4in (6.4mm) inside diameter or tubes having a wall thickness thinner than 0.020in (0.51mm). These tubes shall be tension tested in accordance with ASTM A632.
4.6 Ball Test

4.6.1 Ball test shall be carried on all copper tubes to ensure clear opening of the tube. The OD of the ball shall be minimum 1.0 mm for 6.0mm 00 tube and 2.0 mm for 3/8" (10mm) OD tube.

4.7 Witness Inspection

4.7.1 All tubes shall be offered for pre-dispatch inspection for the following, as a minimum;

   a) Physical dimensional verification and workmanship.

   b) Hardness / tension test for stainless steel tubes.

   c) Hydrostatic and pneumatic tests on representative samples.

   d) Ball test on copper tubes on representative samples.

   c) Eddy current examination of copper tubes on representative samples.

   f) Review of all certificates and test reports as indicated in clause 4.2 of this specification.

4.7.2 In the event that the witness inspection is not carried out by purchaser, vendor shall anyway complete the tests and test reports for the same shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 The tube shall be plugged at both ends to prevent entry of foreign matter.

5.2 The tubes shall be packed carefully so as to avoid damage during transport.

5.3 All tubes III oxygen and chlorine service shall be separately packed along with a certificate indicating ‘SUITEABLE FOR OXYGEN/ CHLORINE SERVICE’, as applicable.

6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents and information which is specifically indicated in the material requisition.

6.2 Any offer not conforming to above requirements, shall summarily be rejected.
## ANNEXURE - 1 : MAXIMUM WORKING PRESSURE AND HYDROSTATIC TEST PRESSURES FOR INSTRUMENT TUBING

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Size of Tube (OD)</th>
<th>Material</th>
<th>Line Pressure Class</th>
<th>Thickness</th>
<th>Maximum Working Pressure</th>
<th>Hydrostatic Test Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>½” (12 mm)</td>
<td>Stainless Steel</td>
<td>≤ 600 #</td>
<td>0.049” (1.2 mm)</td>
<td>102 Kg/cm²g</td>
<td>153 kg/cm²g</td>
</tr>
<tr>
<td>2.</td>
<td>½” (12 mm)</td>
<td>Stainless Steel</td>
<td>&gt; 900 # to ≤ 1500 #</td>
<td>0.065” (1.65 mm)</td>
<td>253 Kg/cm²g</td>
<td>383 kg/cm²g</td>
</tr>
<tr>
<td>3.</td>
<td>¼” (6 mm)</td>
<td>Stainless Steel</td>
<td>≤ 600 #</td>
<td>1.00 mm</td>
<td>102 Kg/cm²g</td>
<td>153 kg/cm²g</td>
</tr>
<tr>
<td>4.</td>
<td>¼” (6 mm)</td>
<td>Stainless Steel</td>
<td>&gt; 900 # to ≤ 1500 #</td>
<td>0.065” (1.65 mm)</td>
<td>253 Kg/cm²g</td>
<td>383 kg/cm²g</td>
</tr>
<tr>
<td>5.</td>
<td>⅜” (10 mm)</td>
<td>Copper</td>
<td>-</td>
<td>0.049”</td>
<td>53 Kg/cm²g</td>
<td>80 kg/cm²g</td>
</tr>
<tr>
<td>6.</td>
<td>⅛” (6 mm)</td>
<td>Copper</td>
<td>-</td>
<td>1.00 mm</td>
<td>53 Kg/cm²g</td>
<td>80 kg/cm²g</td>
</tr>
</tbody>
</table>
STANDARD SPECIFICATION

FOR

INSTRUMENT VALVES AND MANIFOLDS
Abbreviations

CWP       Cold Working Pressure
NPT       National Pipe Thread
PTFE      Poly Tetra Fluoro Ethylene
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3.0 NAMEP LATE
4.0 INSPECTION AND TESTING
5.0 SHIPPING
6.0 REJECTION

ANNEXURE
ANNEXURE - 1: HYDROSTATIC TEST PRESSURES FOR INSTRUMENT VALVES AND MANIFOLDS.
1.0 General

This standard specification shall be used for Instrument Valves and Manifolds.

2.0 DESIGN AND CONSTRUCTION

2.5 The finishing and tolerances of parts like stem, piston, stem threading etc. of the offered Valves and manifolds shall be properly machined to avoid problems like galling.

2.6 The hand wheel material for all valves and manifolds shall be zinc/nickel plated carbon steel. Any other material, if provided as per standard vendor design, shall also be acceptable.

2.7 Instrument Valves (Miniature)

2.7.1 The instrument valves shall be of globe pattern needle valves forged! bar stock with inside screwed bonnet, with back-seated blowout proof system.

2.7.2 Body material shall be 316 Stainless Steel unless otherwise specified.

2.7.3 The minimum cold working pressure (CWP) rating of the valve shall be as per Annexure 1 of this specification, unless otherwise specified.

2.7.4 The end connection shall be 1/2” NPTF to ANSI B1.20.1, unless otherwise specified.

2.7.5 Flow direction shall be marked on the body.

2.7.6 The valve dimensions shall be as follows:
   a) End to end dimensions 76mm (approximately).
   b) Height in fully open condition - 135mm maximum.
   These dimensions are indicative only.

2.8 Valve Manifolds

2.8.1 3-Valve and 5-Valve manifolds:

2.8.1.1 3-Valve manifold
   a) 3-Valve manifold shall be designed for direct coupling to differential pressure Transmitters having 2 bolt flanges with 54mm (2-118") centre-to-centre connections and 41.3mm (1-5/8") bolt-to-bolt distance.

   b) 3-Valve manifold shall contain two main line block valves and an equalizing by pass valve. The valves shall be needle type. They shall use self-aligning 316 Stainless Steel ball seats, unless otherwise specified.

2.8.1.2 5-Valve manifold
   a) 5-Valve manifold shall be designed for direct coupling to differential pressure
Transmitters having 2 bolt flanges with 54mm (2-1/8") centre-to-centre connections and 41.3mm (1-5/8") bolt-to-bolt distance.

b) 5-Valve manifold shall contain two main line block valves and a combination Double block and bleed for the bypass line The valve shall of needle type or special ball With bleed hole.

2.8.1.3 The flanges shall be integral part of manifold block.

2.8.1.4 The material of construction shall be 316 Stainless Steel, unless otherwise specified.
2.8.1.5 The minimum cold working pressure (CWP) rating of manifolds shall be as per Annexure 1 of this specification, unless otherwise specified.

2.8.1.6 The process connection shall be 1/2"NPTF to ANSI B 1.20.1.

2.8.1.7 Wherever the manifolds are specified for stanchion mounting, these shall be supplied along with mounting accessories. The bolts and nuts shall be alloy steel as per ASTM A 193 Gr B7 and ASTM A194 Gr. 2H (Hot dip galvanized or zinc plated) respectively. Other accessories shall be zinc plated.

2.8.2 3 way 2 valve manifolds for pressure gauges

2.8.2.1 The manifold shall be designed for use with pressure gauges with block and bleed valves. The manifold body shall be either straight or angle type as specified in the data sheet.

2.8.2.2 The valve shall be a needle type.

2.8.2.3 The body material shall be 316 Stainless Steel, unless otherwise specified.

2.8.2.4 The minimum cold working pressure rating of the manifold shall be as per Annexure 1 of this specification, unless otherwise specified.

2.8.2.5 The manifold shall have the following connections:

a) The inlet connection shall be %” plain ends with a minimum of 100mm nipple Extension suitable for socket weld or butt weld as per B16.11/ B16.9 as Specified in the job specifications

b) The gauge connection shall be with union nut and tail piece threaded to ½” NPTF.

c) The drain connection shall be ½” NPTF.

2.9 Instrument Air Valves

2.9.1 Instrument Air Isolation Valves (Miniature)

2.9.1.1 The valves shall be full-bore ball type with forged body.

2.9.1.2 Body material shall be 316 Stainless Steel.
2.9.1.3 The minimum cold working pressure rating of instrument air isolation valves shall be as Per Annexure 1 of this specification, unless specified otherwise.

2.9.1.4 The end connection shall be 1/4" NPTF to ANSI B 1.20.1, unless otherwise specified.

2.9.1.5 End to end dimensions shall be 70mm (approximately).

2.9.2 Instrument Air Needle Valves (Miniature)
2.9.2.1 The instrument valves shall be globe pattern-needle valves forged/bar stock with inside Screwed bonnet.

2.9.2.2 Body material shall be 316 Stainless Steel.
2.9.2.3 The minimum cold working pressure of Instrument Air Needle valves shall be per Annexure I of this specification. Unless otherwise specified.
2.9.2.4 The end connection shall be 1/4" NPTF to ANSI B1.20.1, unless otherwise specified.
2.9.2.5 Flow direction shall be marked on the body.

2.9.2.6 The valve dimensions shall be as follows:

a) End to end dimensions - 54 mm (approximately).

b) Height in fully open condition - 49 mm maximum.

These dimensions are tentative only.

2.10 All instrument valves in oxygen and chloride service shall be thoroughly degreased using reagents like trichloroethylene or carbon tetrachloride. End connection shall be plugged after degreasing process in order to avoid entrance of grease or oil particles.

3.0 NAME PLATE

Following information shall be punched on the body of each of these items;

a) Material of construction to the same standards as in purchaser's data sheets.
b) Cold working pressure of each item to the same standards as in purchaser's data sheets.
c) Manufacturer's identification and model number.
d) Flow direction (if applicable)
e) Material of construction.

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at vendor's works, in line with the inspection test plan for instrument valve and manifolds.

4.2 Vendor shall submit following test certificates and test reports for purchaser's review:

a) Material test certificates as per clause 3.1B of EN 10204 for body and bonnet and as per clause 2.2 for other parts.
b) Dimensional test report.
c) Pressure test report as per clause 4.3 of this specification.
4.3 Pressure Test Requirements

4.3.1 Each valve and manifold shall be subjected to hydrostatic pressure test at ambient temperature for both seat and shell leakage at test pressures given in Annexure-I of this specification. During and after the hydrostatic test there shall not be any visible leakage.

4.3.2 Pneumatic Test

Each valve and manifold shall be subjected to pneumatic test for both shell and seat leakage at 7.0 kg/cm-g with testing medium as air at ambient temperature. There shall not be any visible leakage when immersed in water or coated with a leak detection solution.

4.4 Witness Inspection

4.4.1 All valves and manifolds shall be offered for pre-dispatch inspection for following, as a Minimum:

a) Physical dimensional verification and workmanship.

b) Pressure test as per clause 4.3 of this specification on representative samples.

c) Review of all certificates and test reports as indicated in clause 4.2 of this specification.

4.4.2 In the event, when witness inspection is not carried out by purchaser, the tests shall anyway be completed by the vendor and documents for the same shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 The threads/ends shall be protected with plastic caps to prevent damage/entry of foreign matter.

5.2 All instrument valves and manifolds in oxygen and chloride service shall be separately packed along with a certificated indicating 'CERTIFIED FOR OXYGEN/CHLORINE SERVICE' as applicable.

6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per this specification and shall attach only those documents and information, which is specifically indicated in the material requisition.

6.2 Any offer not conforming to above requirements, shall be summarily rejected.
## Annexure-I

### HYDROSTATIC TEST PRESSURES FOR INSTRUMENT VALVES AND MANIFOLDS

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Item</th>
<th>Line Pressure Class</th>
<th>Minimum Cold working pressure (CWP)</th>
<th>Hydrostatic Test Pressure For</th>
<th>Seat leakage Test</th>
<th>Shell Leakage Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Instrument valve (Miniature)</td>
<td>≤ 600#</td>
<td>102 kg/cm² g</td>
<td>112 kg/cm² g</td>
<td>153 kg/cm² g</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 900# to ≤1500#</td>
<td>253 kg/cm² g</td>
<td>278 kg/cm² g</td>
<td>383 kg/cm² g</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Instrument valve (Manifolds)</td>
<td>≤ 600#</td>
<td>102 kg/cm² g</td>
<td>112 kg/cm² g</td>
<td>153 kg/cm² g</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 900# to ≤1500#</td>
<td>253 kg/cm² g</td>
<td>278 kg/cm² g</td>
<td>383 kg/cm² g</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Instrument Air Isolation Valve</td>
<td></td>
<td>27 kg/cm² g</td>
<td>30 kg/cm² g</td>
<td>41 kg/cm² g</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Instrument Air Needle Valves</td>
<td></td>
<td>27 kg/cm² g</td>
<td>30 kg/cm² g</td>
<td>41 kg/cm² g</td>
<td></td>
</tr>
</tbody>
</table>
STANDARD SPECIFICATION

FOR

JUNCTION BOXES AND CABLE GLANDS
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3.0  NAME PLATE

4.0  INSPECTION AND TESTING

5.0  SHIPPING

6.0  REJECTION
1.0 GENERAL

1.1 Scope

1.1.1 This standard specification, together with the data sheets attached herewith, covers the requirements for design, materials, nameplate marking, testing and shipping of junction boxes and cable glands which include the following types:

a) Electrical junction boxes
b) Pneumatic junction boxes
c) Cable glands (whenever specified)

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the purchaser's enquiry;

- **ANSI/ASME** American National Standards Institute / American Society of Mechanical Engineers.
- **B 1.20.1** Pipe Threads, General Purpose (Inch).
- **EN 10204** Inspection Documents for Metallic Products
- **IEC-60079** Electrical Apparatus for Explosive Gas Atmosphere
- **IEC-60529** Degrees of Protection Provided by Enclosures. (IP Code)
- **IS-5** Colours for ready mixed paints and enamels.
- **IS-13947** Specification for Low Voltage Switchgear and Control gear.
- **IS-2148** Electrical Apparatus for Explosive Gas Atmospheres - Flame proof Enclosures 'd'.

1.1.3 In the event of any conflict between this specification, data sheets, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations
b) Data Sheets
c) Standard Specification
d) Codes and Standards

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached alongwith the material requisition.

1.2.2 Deviation on technical requirements shall not be entertained.

1.2.3 Whenever a detailed technical offer is required, vendor's quotation shall include the following;

a) Compliance to the specifications.

b) Whenever the requirement of a detailed specification sheet for each item is specifically indicated, the specification sheet shall provide information regarding type, construction
material. Size and number of cable entries etc. The material specifications and unit of measurement for various parts in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheets.

c) Drawing for each type of junction box with dimensional details (in millimetres) showing the terminal, entries arrangement, mounting details etc.

d) Proven references for each offered model in line with clause 1.2.4 of this specification whenever specifically indicated in purchaser's specification.

e) Copy of certificate for approval of flameproof junction boxes, adapter, plug and cable glands from local statutory authority as applicable such as Chief Controller of Explosive (CCE), Nagpur or Director General Mines Safety in India along with:

i) Test certificate from recognised testing house like CMRI/ERTL etc. as per relevant Indian Standard for all Indian manufactured items or items requiring DGMS approval.

ii) Certificate of conformity from agencies like LICE, BASEEI::A, PTB, CSA, UL etc. for compliance to ATEX or any recognised standard for items manufactured outside India.

f) Catalogues in English giving detailed technical specifications, model decoding details and other related information for each type of junction box and cable gland covered in the bid.

1.2.4 All items, as offered, shall be field proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date in the process conditions similar to those as specified in the purchaser's data sheet. Items with prototype design or items not meeting provenness criteria specified above shall not be offered.

1.2.5 All documentation submitted by the vendor including their drawings, installation manual etc shall be in English language only.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of reproducible, prints and soft copies, shall be sent to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data and installation manual submitted by the vendor after placement of purchase order shall include the following, as a minimum;

a) Specification sheet for each junction box and its accessories like cable glands etc.

b) Certified drawing sheets for each junction box and its accessories, which shall provide dimensional details, internal constructional details (general arrangement details) and material of construction.

c) Copy of type test certificates.

d) Copy of test certificates for all the tests indicated in clause 4.0 of this specification.

e) Installation procedure for junction boxes and its accessories
2.0 DESIGN AND CONSTRUCTION

2.1 Junction Boxes

2.1.1 Junction boxes shall be either of the following type as specified in data sheets.

a) Weather proof junction boxes.
b) Weather proof and flame proof junction boxes.

No other type of junction boxes shall be offered, / supplied unless specifically indicated otherwise.

2.1.2 Unless otherwise specified, the enclosure shall conform to the following standards:

Weatherproof housing : IP 55 to IEC-60529/IS-13947
Flameproof housing : Flameproof IEx (d) as per IEC-60079/IS-2148.

2.1.3 Number of entries and their location shall be as per data sheets. Junction boxes with top entries shall not be offered. The size of cable entries shall be as per the cable sizes indicated in the data sheet.

2.1.4 Multi-pair junction boxes shall be provided with telephone sockets and plugs for connection of hand-powered telephone set.

2.1.5 Electrical Junction Boxes

a) The material of construction of electrical junction boxes shall be die-cast aluminium of minimum 5 mm thick (LM-6 alloy). with anti corrosive paint
b) Weather proof junction box shall have hinged type door with neoprene gasket, which shall be fixed to the box by plated countersunk screws.
c) Flameproof junction box shall have detachable cover, which shall be fixed to the box by means of cadmium plated triangular head/hexagonal head screws.
d) Flameproof junction boxes for signal, alarm and control shall have the following warning engraved/integrally cast on the cover; "Isolate power supply elsewhere before opening"
e) Power junction boxes (junction boxes for power supply cable / distribution) shall have either the warning cast or shall have warning plate with following marking;

"Isolate power supply elsewhere before opening".

Unless otherwise indicated in the job specification, power junction boxes shall be suitable for incoming armoured power cable up to 150 sq.mm conductor size.
f) Terminals shall be spring loaded, vibration proof, clip-on type, mounted on nickel plated steel rails complete with end cover and clamps for each row.

g) All terminals used in signal, alarm and control junction boxes shall be suitable for accepting minimum 2.5 sq.mm copper conductor, in general.

h) Terminal used in power junction boxes / power supply distribution box shall be suitable for accepting conductor size of 4 Sq. mm to up to 120 sq. mm. Exact requirement shall be specified in job specification. Higher size of terminals shall be provided when indicated. Bus bar terminals shall be provided for conductor size 50 sq.mm and above. Suitable size of lugs shall be provided to suit conductor size specified.

i) Each junction shall have minimum of 30% spare terminal of those actually required to be utilised. Unless higher number of terminal are specified in the purchaser's data sheet, the number of terminals for various types of junction boxes shall be as follows;

- 24 Nos for 6 pair junction box.
- 48 Nos. for 12 pair junction box
- 36 Nos for 6 triad junction box.
- 48 Nos. for 8 triad junction box.

j) Terminals shall be identified as per the type of input signal indicated in data sheets e.g all terminals for intrinsically safe inputs shall be blue while others shall be grey in colour.

k) Junction boxes shall be provided with external earthing lugs.

l) Sizing shall be done with due consideration for accessibility and maintenance in accordance with the following guidelines;

i) 50 to 60 mm gap between terminals and sides of box parallel to terminal strip for up to 50 terminals and additional 25 mm for each additional 25 terminals.

ii) 100 to 120 mm between two terminal strips for upto 50 terminals and additional 25 mm for each additional 25 terminals.

iii) Bottom/top of terminal shall not be less than 100 mm from bottom / top of the junction box.

2.1.6 Pneumatic Junction Boxes

a) Pneumatic junction boxes shall be made of 3 mm thick hot rolled steel, They shall have necessary neoprene gasket between door and body. Door shall be flush with the box and shall be hinged type and provided with wing nuts.

b) Single tube entries shall be suitable for 6 mm 0.0 copper tube with bulk head fittings. Multi tube bundle entry shall be suitable for the data furnished in data sheets.

2.1.7 Painting
a) Surface shall be prepared for painting. It shall be smooth and devoid of rust and scale.

b) Two coats or lead-free base primer and two final coats of lead free epoxy based paint shall be applied both for interior and exterior surfaces.

c) The colour shall be as specified in data sheets. However, following philosophy shall be followed, in general:

(i) Light blue for all intrinsically safe junction boxes.

(ii) Light grey for all others

2.2 **Cable glands, Plugs and Reducers/Adaptors**

2.2.1 Cable glands shall be supplied by vendor whenever specified.

2.2.2 Cable glands shall be double compression type for use with armoured cables.

2.2.3 The cable glands shall be of SS316, as minimum.

2.2.4 The cable glands shall be weatherproof. Whenever specified they shall also be flameproof and certificate for the specified electrical area classification specified in the data sheets.

2.2.5 Cable glands shall be supplied to suit the cable dimensions indicated along with tolerances in data sheets. Various components like rubber ring, metallic ring, metallic cone and the outer / inner nuts etc. shall be capable of adjusting to the indicated tolerances of cable dimensions.

2.2.6 Reducers / adapter s shall be supplied as per details indicated in data sheets. They shall be nickel plated brass, as a minimum. These shall also be weatherproof and / or flame proof wherever specified and certified for the electrical area classification specified in the data sheets.

2.2.7 Plugs shall be provided wherever specified. They shall be SS316, All JB extra entries shall be plugged

2.2.8 All Plugs shall be SS316, certified flameproof when used with flameproof junction boxes.

3.0 **NAMEPLATE**

3.1 Each junction box shall have an anodised aluminium nameplate permanently fixed to it at a visible place furnishing the following information;

a) Tag number as per purchaser’s data sheet.

b) Manufacturer's serial number and model number.

c) Manufacturer's name / trade mark.

d) Stamp of certifying agency with certificate number.

e) Electrical area classification.
4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at the vendor's works in line with inspection test plan for junction boxes and cable glands.

4.2 Vendor shall submit following test certificates and test reports for purchaser's review:
   a) Material test certificates as per clause 2.2 of EN 10204
   b) Pressure test on castings for £1amproofjunction boxes.
   c) Dimensional test report.
   d) High voltage and msulation resistance test report.
   e) Air leak test report on pneumatic junction boxes.
   f) Certificate from statutory body for suitability to install in specified hazardous area.

4.3 Witness Inspection

4.3.1 All Junction boxes, cable glands and other accessories shall be offered for pre-dispatch inspection for the following. as a minimum:
   a) Physical dimensional verification and workmanship on representative samples.
   b) High voltage and Insulation resistance test on representative samples.
   c) Air leak test report on representative samples of pneumatic junction boxes.
   d) Review of all certificates and test reports as indicated in clause 4.2 of this specification.

4.3.2 In the event when witness inspection is not carried out by purchaser, the tests shall anyway be completed by the vendor and documents for the same shall be submitted for scrutiny of purchaser.

5.0 SHIPPING

5.1 All threaded openings shall be suitably protected to prevent entry of foreign material.

5.2 All threaded components shall be protected with plastic caps to prevent damage of threads.

6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents, which are specifically indicated in the material requisition.

6.2 Any offer not conforming to above requirements, shall be summarily rejected.
STANDARD SPECIFICATION FOR

MOTORISED ACTUATOR
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# LIST OF ATTACHMENTS

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</table>
1.00 GENERAL

1.01 This general specification together with the Instrument specification attached herewith define the technical requirement for the supply of Motorised gate valve, its spares, documentation and testing.

1.02 In the event of any conflict between general specification and Instrument specification the later shall prevail.

2.00 CODES AND INDUSTRY STANDARDS

The design shall be made in accordance with latest Codes & Standards and statutory requirements.

AMERICAN PETROLEUM INSTITUTE (API)
API 600 Steel Valves - Flanged & Buttwelding Ends
API 6D Specification for Pipeline Valves (Gate, Plug, Ball and Check Valves)
API 598 Valve Inspection & Testing

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)
ASME Boiler and Pressure Vessel Code, including all mandatory addenda
Section VIII, "Pressure Vessels - Division 1"
ASME B2.1, "Screw Threads - Pipe Threads, General Purpose (Inch)"
ASME B16.5, "Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24"
ASME B16.11, "Forged Steel Fittings, Socket-Welding and Threaded"
ASME B16.20, "Metallic Gaskets for Pipe Flanges - Ring-Joint, Spiral-Wound, and Jacketed"
ASME B16.25, "Buttwelding Ends"
ASME B16.34, "Valves – Flanged, Threaded and Welding End"
ASME B16.47, "Large Diameter Steel Flanges NPS 26 Through NPS 60"

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
ASTM A193/A193M, "Alloy Steel and Stainless Steel Bolting Materials for High-Temperature Service"
ASTM A194/A194M, "Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service or Both"
ASTM A320/A320M, "Alloy-Steel Bolting Materials for Low-Temperature Service"
ASTM A350/A350M, "Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components"
ASTM A352/A352M, "Steel Castings Ferritic and Martensitic for Pressure-Containing Parts Suitable for Low-Temperature Service"

AMERICAN WELDING SOCIETY (AWS)
AWS A5.13, "Solid Surfacing Welding Rods and Electrodes"

FLUID CONTROL INSTITUTE (FCI)
FCI 70-2, "Control Valve Seat Leakage"

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)
IEC 60079, "Electrical Apparatus For Explosive Atmospheres"
3.01 Motorised Actuator

The motor shall be conforming to Ex"d", Gas group IIC, T3.

The design, manufacture and performance of equipment covered by this specification shall conform to the relevant Indian/ International standards and codes. In particular the equipment offered shall conform to the following standards with latest revision.

<table>
<thead>
<tr>
<th>Specification Code</th>
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<tr>
<td>IS-325</td>
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<td>IS-2148</td>
<td>Flame proof enclosures of electrical apparatus</td>
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<td>IS-2959</td>
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<td>IS-4691</td>
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<td>IS-4722</td>
<td>Specification for rotating electrical machine</td>
</tr>
<tr>
<td>IS-9334</td>
<td>Specification for electric motor operated actuators</td>
</tr>
</tbody>
</table>

3.02.01 The following devices shall be supplied as integral part of the actuator:

- Electrical drive motor

3.02.011 Electrical drive motor

3.02.012 All the accessories required for safe operation and control of actuators shall be included in the scope of supply but not limited to the following:

- Electrically and mechanically interlocked contractors for opening and closing direction.
- Fuses and thermal overload relay for protection of motor and control transformer.
- Push buttons for opening/ closing and stopping of valve operation.
- Thermostat/ thermister with electronic controller for protection of motor.
- Separate torque and travel limit switches for both Open and Close positions.
- Incoming power supply isolating switch.
- Indicating lamps for valve fully open, fully closed and ‘in-travel’ condition.
- Space heater preferably with control thermostat.
- Local continuous position indicator.
- Terminal block fully pre-wired upto contacts on individual devices.
- Control transformer
- 2 nos. earthing terminals.
- Hand wheel for manual operation, suitably interlocked to prevent simultaneous manual and electrical operation.

3.02.02 The housing material for actuator shall be anodised aluminium alloy and shall be epoxy painted. Vendor to furnish the thickness and type of paint.

3.02.03 The motor shall be electrical three-phase squirrel cage induction type. The motor enclosure shall be flame proof as per specification sheets and shall conform to IP – 68 or better. The motor design & construction shall be robust, long maintenance free service life. The motor shall be rated for short time duty 5-15 minutes. Motor shall be able to operate the actuator at 75% of the specified voltage. Motor shall have F class insulation (Temperature rise class B) and winding shall be resistant to corrosive agents such as NH₃, CO₂ and moisture. Fuses and thermal overload relay shall be provided for protection of motor and control transformer. Electrical and
mechanical disconnection of the motor should be possible without draining the lubricant from the actuator gearcase.

The motor shall be suitable for the following conditions -

a) Minimum 3 numbers of consecutive starts in hot condition.

b) Minimum 8 no. of starts in time span of 15 minutes.

3.02.04 Push buttons for opening/ closing/ stopping the valve action in the field to be provided. Contact for push buttons shall be "Normally open" type.

3.02.05 Lockable selector switch for “local/off/remote” operation of the valve shall be provided as follows:

1. Position local : The actuator can be operated locally.

2 Position off : The actuator is completely off and cannot be operated either from local control switch or from remote control switch.

3 Position remote : The actuator can be operated only from remote control point. It is not possible to operate it from local control switch.

3.02.06 Torque switches shall be provided for opening and closing direction.

3.02.07 Local indicating lamps for valve fully open (green) and fully closed (red) condition to be provided.

3.02.08 Space heater with thermostat shall be provided.

3.02.09 Control transformer shall be supplied.

3.02.10 Actuator shall have three cable entries :

(i) For Power supply (1 1/2"NPT)

(ii) For remote operation & position indication (1"NPT)

(iii) Spare (1" NPT plugged).

Cable glands shall be double compression, flame proof type of SS material.

3.02.11 Actuator shall be flame proof confirming to Exd IIC T3 as per IEC with environmental protection of IP 65 or better. All the bolts and nuts used in the actuator, bonnet and other parts of the valve body shall be made of stainless steel. The actuator shall be oversized to at least 25% of sizing.

3.02.12 Actuator shall be provided with following control status indicated on DCS/ PLC:

- Valve opening, closing or moving
- Valve full open
- Valve full close
- Valve position at intermediate
- Motor tripped on torque in mid travel, motor stalled
- Remote selected
- Actuator being open by handwheel

3.02.13 The actuator shall include a digital position indicator with a display from fully open to fully closed in 1% increment. Provision shall be made to orientate the display through increment of 90%. Provision shall be made in design for the addition of a contactless transmitter to give a 4-20 mA analog signal corresponding to valve travel for remote indication when required and actuator output torque for remote indication when required.
3.03 Accessories

3.03.01 Limit switches shall be weatherproof IP-65 or better. Limit switches shall be supplied for valve open and close positions suitable for low current intrinsically safe applications (gold plated contacts of 24V DC 1 A rating).

3.03.02 wherever handwheel has been specified, the same shall be side mounted type and engaged when the motor is declutched by a lever or similar means, the drive being restored to power automatically by starting the motor. The handwheel or selection lever shall not move on restoration of motor drive. Provision shall be made for the hand/ auto selection lever to locked in both hand and auto position. While the hand/ auto selection lever is locked in auto mode, without damage to the actuator motor it should be possible for hand operation while the motor actuator is in running condition or in starting condition. The handwheel drive must be mechanically independent of the motor drive and any handwheel gearing should be such as to permit emergency manual operation in a reasonable time. Clockwise operation of the handwheel shall give closing movement of the valve unless otherwise started. Neutral position of the handwheel shall be clearly indicated.

3.03.03 The actuator shall be furnished with a drive bushing easily detachable for machining to suit the valve stem or gearbox input shaft. Normally the drive bush shall be positioned in a detachable base of the actuator. Thrust bearing, when housed in a separate thrust base should be of the sealed for life type.

3.03.04 The reversing starter, control transformer and local control shall be integral with the valve actuator suitably housed to prevent breathing and condensation. The starter shall be suitable for 60 starts per hour and of rating appropriate to motor size. The starter contactors shall be protected from excessive current surge during travel reversal by an automatic time delay on energization of contactor coils. The controls supply transformer shall be fed from two of the incoming three phase and incorporate overload protection. It shall have the necessary tapping and be adequately rated to provide power for the following functions: -
   - Energization of contactor coils
   - 24 VDC output where required for remote controls
   - Supply for all the internal electric circuits

3.04 Fugitive Emissions Considerations

Packing shall limit fugitive emissions. Fugitive emissions of any substance containing more than 5% by weight of volatile hazardous air pollutant as defined in the National Emissions Standard for Organic Hazardous Air Pollutants (NESHAP) shall be limited in accordance with the applicable local regulation or to a maximum of 500 parts per million, whichever is more stringent.

4.00 INSPECTION, FACTORY TESTS AND APPROVAL

4.01 All instruments and accessories shall be inspected & tested to ascertain that the supply is in accordance with approved specification. The inspections & tests shall not relieve the supplier/ manufacturer from his responsibilities for materials and the performance of the instrument supplied.
Within two weeks of receipt of the Letter Of Intent (LOI) /order, vendor must contact the Inspection Agency specified in the order and finalise with them the Quality Assurance Plan (QAP) for carrying out Inspection and test.

In absence of any Inspection Agency the vendor must submit the Quality Assurance Plan for principal’s approval. All tests, in such cases, shall be conducted by manufacturer’s quality department and the results of tests shall be forwarded alongwith the supply.

Procedure and extent of tests shall be governed by QAP mutually agreed between the vendor and principal’s inspection authority.

No instrument / accessory shall be shipped until all the required tests are successfully completed and certified “Cleared for despatch” by the inspection authority.

4.02 The following physical checks, routine tests, as a minimum shall be witnessed by Principal’s inspection authority.

1. Physical Check

a) Physical conformity of the motorised gate valve and its accessories with order specifications including dimensions check -
   - Markings
   - Overall dimensions
   - Face to face body dimension
   - Flanges
   - Thickness check
   - Check for accessories, connections & installations.
   - Test of electrical parts & verifications of hazardous area

In order to check the internal parts the inspector shall have the right to disassemble one valve per type.

2. (i) Routine test for valve

a) Valve inspection and testing shall be in accordance with API 598
b) Hydrostatic testing shall be done in accordance with API 6D, in not it will be tested as per ANSI B 31.3. Unless otherwise stated on the data sheet, component testing of the pressure boundary parts is permitted; provided the valve body assembly is subsequently tested to verify the pressure sealing integrity of gaskets..

c) Seat leakage test with leakage rate conforming to FCI 70.2.

d) Functional tests : If applicable
   - Valve position on energy failure
   - Limit switches
   - Electric actuator
   - Handwheel

e) The following checks shall be carried out on the valves successfully tested :
   - Rust proof painting (except for SS)
   - Cleaning of internal parts of body
   - Protective plugs against infiltration of foreign materials
   - Protection against possible impacts
   - Valve tag plates

f) Fire safe testing as per API 6FA
g) Radiography/ultrasonic test shall be carried out for all valves of rating above 600#. In addition butt weld ends of all butt welded valves for all pressure ratings shall be subjected to radiography/ultrasonic tests.

h) Magnetic Particle or Die Penetrate test for castings and forging shall be carried out as required.

i) Checking of material composition & test.

j) An alloy verification plan will be issued on projects where alloy verification is required in accordance with General Engineering Procedures. This plan will include instrument items to be alloy verified (with verification class defined), required methods of verification and when and where these test are to be performed. Alloy verification requirements will be noted on each valve data sheet (example: “CLASS I ALLOY VERIFICATION REQUIRED”). Supplier shall perform all required tests to meet the stated requirements.

k) Valve shall be subjected to 10% hardness test for hard facing.

2 (ii) Routine test for actuator
Each actuator must be performance tested and individual test certificates shall be furnished. The test equipment should simulate a typical valve load, and the following parameters should be recorded.
(a) Current at max. torque setting
(b) Torque at max. torque setting
(c) Flash test voltage
(d) Actuator output speed or operating time

In addition the test certificate should record details of specifications such as gear ratios for both manual & automatic, drive closing direction, wiring diagram code number etc.

5.00 PACKAGING

Requirement of packaging stated elsewhere in the bid document. Vendor should furnish storage requirement of the valves like Valve should be stored open or close? Does the valve need to be stroked if stored for an extended period? Other requirements.

6.00 IDENTIFICATION AND MARKING

6.01 Self adhesive tapes or signs are not permissible for permanent marking of any instrument.

6.02 Each gate valve shall be fitted with a SS tag plate and shall contain the following information:
- Tag no.
- Manufacturer’s name, Serial No. and Model
- Body and trim material and sizes
- Body rating and end connection
- Fall action

Each motorised actuator shall be fitted with a SS tag plate and shall contain the following information:
- Tag no.
- Torque rating
- Power rating
- Power supply

A durable terminal identification card showing plan of terminals shall be provided and attached to the inside of terminal box cover indicating wiring diagram number terminal layout.

Besides the above each instrument shall have a separate circular tag number plate in stainless steel with engraved tag number and range and attached securely to the instrument with a soft stainless wire. The size of letters and figures shall be minimum 4mm and the plate should be 25mm diameter with 1-2 mm thick. Also each instrument shall have lamicoid nameplate with 6 mm minimum size black letters on white background and identified with their relevant loop number.

6.03 All spare parts shall be fitted with identification plate with the following data clearly printed and easily readable.
- Spare parts name/model no. as per purchaser's Instrument specification sheet
- Serial no.

7.00 SPARES

Spare shall be as per enclosed spares list.

8.00 DOCUMENTATION

1 Technical documentation

1.1 General

All the documentation such as graphic drawings and technical specifications shall be sent to the Contractor who will reserve to approve it within 15 days; after this period, the documents have to be retained approved. The Contractor's approval will not relieve the Vendor of his responsibility for the final performance of the supply. Final issue of Project Documents shall be supplied in electronic format as specified hereunder. All the other Vendor documentation, such as Manual, Catalogues, etc. shall be supplied on paper.

1.2 Title block and heading

Each document originated by the Vendor shall be numbered according to Vendor procedure.

1.3 Specification, Data Sheet and other documents.

All shall be produced with Microsoft Office products as Word, Excel or PowerPoint access. The files shall be delivered in a “workable stand-alone” format, without any special features (links to other files, special fonts, macros, etc.), which may affect the possibility of viewing and editing.

1.4 Drawings

Drawings will be made using AutoCAD version 12 or 14 or Latest. Vendors are permitted to utilise other CAD software, but the produced files are to be converted in AutoCAD format prior the delivery to Contractor. Drawings files shall be delivered as “single complete file”, without any reference attached, except when not practicable due to the dimension of referenced files. In this case together with the reference files also the information necessary to manage the files shall be given.
Together with the drawings files also the relevant files for plotting format HPGL or HPGL2 are to be delivered.

1.5 Scanned documents

The format of scanned documents shall be CCITT Group IV TIFF or Adobe PDF Acrobat. Quality control on file of scanned documents will be completed prior to delivery, including:
Deskew
Despeckle
Hole Fill.
Resolution below 200 Dpi is not acceptable.
The following documents (Technical) are required to be submitted by the vendor along with bid, after placement of order for approval purposes and final documentation before despatch of consignment.

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<th>Description of document</th>
<th>Alongwith bid</th>
<th>After placement of order</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>For approval/ information within two weeks</td>
</tr>
<tr>
<td>1.</td>
<td>Consolidated list of drawings &amp; documents</td>
<td>Yes</td>
<td>Yes (I)</td>
</tr>
<tr>
<td>2.</td>
<td>Deviation, if any, from the technical spec. giving justification for the same.</td>
<td>Yes</td>
<td>x</td>
</tr>
<tr>
<td>3.</td>
<td>Catalogue / technical literature of valves and accessories including cross-sectional view, dimensions, weight etc.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>4.</td>
<td>Tentative dimensional drawings for each Tag No. with technical details like dimensions, weight, special supports, clearances required for easy maintenance etc.</td>
<td>Yes</td>
<td>x</td>
</tr>
<tr>
<td>5.</td>
<td>Final certified detailed as per Sl. No. 4 for main item &amp; accessories for each tag no.</td>
<td>x</td>
<td>Yes (A)</td>
</tr>
<tr>
<td>6.</td>
<td>Material test certificates from independent recognised agency showing chemical analysis, physical analysis, Ferrite content on finished products.</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>7.</td>
<td>Certificates conforming to specific standards from independent recognised agency, wherever applicable, for - Ex-proof items - Intrinsically safe items - Environmental protection - Fire safety</td>
<td>Yes</td>
<td>x</td>
</tr>
<tr>
<td>8.</td>
<td>Manuals for installation, operation &amp; maintenance</td>
<td>x</td>
<td>x</td>
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<td>9.</td>
<td>Calculation sheet for actuator sizing etc. for each tag no. including KW rating</td>
<td>Yes</td>
<td>Yes(I)</td>
</tr>
<tr>
<td>10.</td>
<td>Calibration certificates for - Hydrostatic test Seat leakage test Performance test Functional test Special test (if specified) (radiography, ultrasonic etc.)</td>
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<td>”As supplied” data sheet signed by qualified engineer</td>
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<td>Manufacturer’s quality assurance certificate for each actuator</td>
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<td>Quality assurance plan</td>
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NOTES
1. (A) for Approval (I) for information only
2. Sl. No. 1 to 12 shall be forwarded to Owner as per details outlined in enquiry /order.
3. Sl. No. 13 shall be mutually finalised with Inspection Authority specified in the order as per clause no.4.01.
4. Number of sets shall be as stipulated elsewhere in the bid document. Final documentations shall be supplied in hard copies as well as soft copies in CD formats. Applicable software are MS Office 2000, Word, Access, Excel. Documentation language shall be English.
9.0 METHOD OF TENDERING

General

The Bidder shall present a list of previous applications (References) for equipment similar to the equipment proposed.

Technical information

The equipment offered as a basis shall be of standard production type it shall be based on modern technology, be of a proven and referenced type and designed for continuous operation under the specified operating conditions.

The Bidder shall quote for the materials requested according to the requirements of this specification and of the individual job specifications. With bid shall be supplied the technical documentation.

Deviations

The tender shall be in strict accordance with Purchaser's specifications.

However, the Vendor may quote, in addition and as an alternative, different materials from those required in the specifications, provided these materials are suitable for the process conditions specified in the individual job specifications.

Any deviation from the requirements listed in the general specification and in the individual job specifications shall be clearly highlighted.

If no exceptions are listed, the tender - and the possible supply - shall be regarded as being in full conformity with the Purchaser's requirements, and will be accepted after the tests and checks have confirmed that the performance complies with the requirements of the tender documents and order specifications.
Annexure – I Actuator torque Specification

Note: - Vendor to fill the table for all the tags.

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1
STANDARD SPECIFICATION

FOR

GAS DETECTORS
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1. GENERAL

(1) This specification covers the common and minimum requirements for design and manufacturing of the Gas Detectors.

(2) The design and manufacturing shall be carried out in accordance with this specification together with Codes and Standards to the extent described in this specification.

(3) In case there is any conflict among the requirements, the following priority shall govern.
   1\textsuperscript{ST} Data Sheets
   2\textsuperscript{ND} This Specification
   3\textsuperscript{RD} Codes and Standards

Vendor to bring to the notice of owner/purchaser of any conflict on above documents before proceeding with procurement engineering. If no information is highlighted by vendor during quotation stage it will be presumed by owner purchaser that the vendor is in full compliance to purchaser specification.

(4) The instruments selected for the units shall be rugged in design and must be well proven in the hydrocarbon industry. Prototype design or equipment of experimental nature or design undergoing testing etc. shall not be selected and supplied.

(5) The instruments as being offered supplied should have been operating satisfactorily in a hydrocarbon industry like Refinery, Petrochemical and Gas Processing Plant under similar process conditions for atleast 4000 hours from the bid opening date.

2. CODES AND STANDARDS

(1) ANSI 61.20.1 Pipe threads General Purpose (Inch)
(2) IEC International Electrochemical Commission
(3) NEC National Electric Code
(4) 6SEN5004 Electric Gas Detector for combustible gases.
(5) IEC79 Electrical Apparatus for Explosive Gas Atmosphere.
(6) CSA Standard, C22.2No152, Combustible Gas detection Instruments.

3. ENVIRONMENT CONDITION

The equipment supplied shall be suitable for the ambient temperature which may rise to 45°C with corresponding humidity of 100%

The vendor shall supply Gas Detectors with protective measures (If any) against the climatic condition indicated below.
Barometric Pressure, mbar : Refer document no 1075-0000-0790

Temperature (Design conditions) : Max.45°C  
Min  5°C  
35°C for process calculation

Relative Humidity (RH %) : Refer document no 1075-0000-0790

Rainfall : Refer document no 1075-0000-0790

Wind data : Refer document no 1075-0000-0790

Elevation above mean Sea level. : Refer document no 1075-0000-0790

4. TECHNICAL REQUIREMENTS:

4.1 Catalytic Combustion Type H2 Gas Detectors

4.1.1 Type of Sensor

In general, Catalytic combustion type sensor for combustible gas shall be used.

4.1.2 H2 gases shall be continuously detected by catalytic combustion type Gas detectors.

4.1.2 Electrical Requirement

(A)Transmitter Output :- (x) 4-20mA, 3 WireType.

(B)Range of Instrument: - 0-100% LEL

(C)Operating Voltage: (x) 24VDC  
( ) 110VAC  
( ) 230VAc

(D)Response Time:- Less than 10 Sec for 90% of Full scale

(E) Display: - (x) Required  
( ) Not Required

4.1.4 Enclosure

(1) Materials  (x) Die Cast Aluminum  ( ) Manufacturer Standard

(2) Enclosure class: 

STANDARD SPECIFICATION FOR

GAS DETECTORS

( ) Weatherproof ( ) General purpose
(x) Explosion proof
- Class: ( ) As spec in Instrument Data/ Schedule sheets
- Suitable for IEC Zone 2 Group II A + IIB + H2,
- Authority's certificate: (x) Yes ( ) No

(x) All gas detectors shall be certified to the specified hazardous area by a statutory body like CSA, BASEEEFA, PTB, LCIE, UL, and etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

(x) CCOE (Chief Controller of Explosives)

(3) Weather hood: (x) Yes ( ) No

(x) For rain
(x) For dust
( )

(4) Cable Entry:
    (x) WNPT (F)
    ( ) G1/2 in.

4.1.5 Mounting:
    (x) 2 in. pipe mounted
    ( ) Mounting stand

4.1.6 Accessories:- 2" Pipe Mounting Accessories, Cable Glands & plugs.

All ex-proof components /instruments should have Chief Control of Explosives (CCOE)- Nagpur certification.
All sensors shall be resistant to sulphur poisoning & withstand salt laden amb. Condition for the specified life period.

4.2 Infrared type HC gas detector

4.2.1 Type of Sensor

Infrared type sensor for hydrocarbon gas shall be used.

4.2.2 Hydrocarbon (HC) gases shall be continuously detected by Infrared type gas detectors

4.2.3 Electrical Requirement

(A) Transmitter Output:- (x) 4-20 mA, 3 Wire type
(B) Range of Instrument:- 0-100% LEL
(C) Operating Voltage: (x) 24VDC
    ( ) 110VAC
    ( ) 230VAC

(D) Response Time:- Less than 5 sec.
(E) Display:- (x) Required
4.2.4 Enclosure

(1) Materials  (x) Die cast aluminum epoxy coated ( ) Manufacturer std.

(2) Enclosure Class
   ( ) Weatherproof  ( ) General purpose
   (x) Explosion proof (Ex’d’)
      - Class: ( ) As spec in Instrument Data/ Schedule sheets
        (x) Suitable for IEC Zone 2 Group IIA +IIIB+H2,
        - Authority's certificate: (x) Yes ( ) No

   (x) All gas detectors shall be certified to the specified hazardous area by a statutory body like CSA, BASEEFA, PTB, LICE, UL, and etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

   (x) CCOE (Chief Controller of Explosives)

(3) Weather hood: (x) Yes ( ) No
   (x) For rain
   (x) For dust
   ( ) __________

(4) Cable Entry:  (x) WNPT (F)
   ( ) G1/2 in

4.2.5 Mounting:
   (x) 2 in. pipe mounted
   ( ) Mounting stand

   All sensors shall be resistant to sulphur poisoning & withstand salt laden amb. Condition for the specified life period

4.2.6 Accessories: - 2" Pipe Mounting Accessories, Cable Glands & plugs.

4.3 Electrochemical Gas Detectors

4.3.1 Type of Sensor

   Electrochemical gas sensor for Co gas shall be used.

4.3.2 CO gases shall be continuously detected by electrochemical type Gas detectors.

4.3.3 Electrical Requirement:
STANDARD SPECIFICATION FOR
GAS DETECTORS

(A) Transmitter Output:-(x) 4-20 mA, 3 Wire type
(B) Range of Instrument:-(x) 0-100 ppm
(C) Operating Voltage:-(x) 24VDC
(L ) 110VAC
(L ) 230VAC
(D) Response Time:-Less than 30 sec for 50% full scale.
(E) Display:-(x) Required
( ) Not Required

4.3.4 Enclosure

(1) Materials -(x) Die cast aluminum epoxy coated ( ) Manufacturer std.

(2) Enclosure Class:
( ) Weatherproof ( ) General purpose

(x) Explosion proof (EEx’d’)
-Class: ( ) As spec in Instrument Data/ Schedule sheets
(x) Suitable for IEC Zone 2 Group IIA +IIB+H2,
- Authority's certificate: (x) Yes ( ) No

(x) All gas detectors shall be certified to the specified hazardous area by a statutory body like CSA, BASEEFA, PTB, LCIE, UL, and etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

(3) Weather hood: (x) Yes ( ) No
(x) For rain
(x) For dust
( )

(4) Cable Entry: (x) WNPT (F)
( ) G1/2 in

4.3.5 Mounting:

(x) 2 in. pipe mounted
( ) Mounting stand.

4.3.6 Accessories:- 2” Pipe Mounting Accessories.

All sensors shall be resistant to sulphur poisoning & withstand salt laden amb. Condition for the specified life period.

4.4 Catalytic type gas detectors

4.4.1 Type of Sensor

Catalytic type gas sensor for ammonia gas shall be used.
4.4.2 Ammonia gases shall be continuously detected by Catalytic type Gas detectors.

4.4.3 Electrical Requirement:

(A) Transmitter Output: (x) 4-20 mA, 3 Wire type
(B) Range of Instrument:- 0-100 ppm
(C) Operating Voltage: (x) 24VDC
                          ( ) 110VAC
                          ( ) 230VAC
(D) Response Time: Less than 60 sec with splash guard & dust guard.
(E) Display:  (x) Required
           ( ) Not Required

4.4.4 Enclosure

(3) Materials (x) Die cast aluminum epoxy coated ( ) Manufacturer std.

(4) Enclosure Class:
   ( ) Weatherproof ( ) General purpose

(x) Explosion proof (EEx’d’)
   - Class: ( ) As spec in Instrument Data/ Schedule sheets
     (x) Suitable for IEC Zone 2 Group IIA +II B+H2,
     - Authority’s certificate: (x) Yes ( ) No

(x) All gas detectors shall be certified to the specified hazardous area by a statutory body like CSA, BASEEFA, PTB, LCIE, UL, and etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

(3) Weather hood: (x) Yes ( ) No

   (x) For rain
   (x) For dust
   ( )

(4) Cable Entry: (x) WNPT (F)
                ( ) G1/2 in

4.4.5 Mounting:

   (x) 2 in. pipe mounted
   ( ) Mounting stand.

4.4.6 Accessories: - 2” Pipe Mounting Accessories.

   All sensors shall be resistant to sulphur poisoning & withstand salt laden amb. Condition for the specified life period.

4.5 HOOTERS

1) The Hooters shall be of electric type.
2) The Hooter shall be pre-assembled with SOV & AFR.
3) The SOV shall confirm to the below requirements.
   a) The SOV shall be suitable for locating in Zone2, Gr IIA+ IIB+ H2 hazardous area.
   b) The SOV shall be intrinsically safe, the intrinsically safe enclosures shall be certified
to the specified hazardous area by a statutory body like CSA, BASEEFA, PTB, LCIE, 
FM, UL, and etc. for compliance to ATEX directives or other equivalent standards for
all equipments manufactured outside India. In addition to this for instruments installed
in hazardous area, CCOE (Chief Controller of Explosives), Nagpur certification shall
be required.
   c) The solenoid valve shall be direct acting type, three-way, Universal type, shall be
continuous rated type with class H insulation as per IEC60085/1S1271.
   d) The body shall be of SS with SS316 trim as minimum, and be operated on 24 VDC.
   The SOV vent shall have bug screens.
   e) SOV shall have integral junction box with WNPT (F) cable entry. Flying leads are not
acceptable.
   f) The SOV shall be SIL-2 certified.
4) The AFR shall confirm to the below requirements.
   a) Filter mesh shall have 5 micron sintered bronze 1 ceramic filter element and shall be
provided with manual drain.
   b) The AFR shall have a 2" pressure gauge; the pressure gauge shall be of SS
material.
   c) The connection size for instrument air on AFR shall be clearly indicated.
5) Suitable wall mounting assembly shall be provided with the Hooter.

4.6 BEACONS

1) The beacons shall be of flashing type.
2) The beacons shall be Ex-proof Ex'd' suitable for locating in Zone2, Gr.II A + IIB+H2, hazardous area.
3) The beacons shall be certified to the specified hazardous area by a statutory body like CSA, 
BASEEFA, PTB, LCIE, UL, and etc. for compliance to ATEX directives or other equivalent 
standards for all equipments manufactured outside India. In addition to this for instruments installed 
in hazardous area, CCOE (Chief Controller of Explosives), Nagpur certification shall be required.
4) The beacons shall operate on 24VDC power supply.
5) The cable entry shall be WNPT (F).
6) Suitable wall mounting assembly shall be provided with the Beacon.

4.7 CALIBRATION ACCESSORIES

Vendor to provide following accessories:
   (a) Calibration gases shall be provided for warranty period.

4.8 MARKING

Each gas detector shall be marked according to MSS-SP-25. The material of the name plate
shall be of SS316 & fully insulated. A name plate engraved with following shall permanently be
affixed on each detector.

Tag Number
Manufacturer's Name
Model Number
Serial Number
4.9 Portable gas detector shall be supplied, one no. each for HC application.

5 INSPECTION AND TESTING:

(1) The testing and acceptance shall be carried out on the mutually agreed procedures and criteria based on this specification and vendor’s standard procedures.

(2) The Owner/Purchaser shall be free to request any specific test on any equipment considered necessary by him although not listed in this specification, including proper workmanship & materials, as a part of approval of testing procedure. The cost of performing all tests shall be borne by the vendor, without affecting the overall delivery schedule.

(3) Vendor to note that acceptance of any equipment or the exemption of inspection or testing shall in no way absolve the vendor of the responsibility for delivering the equipment meeting all the requirements specified in Material Requisition. It shall be vendor’s responsibility to modify and/or replace any hardware if the specified functions are not completely achieved satisfactorily during Inspection and Testing.

(4) Vendor shall make available all consumable instruments & equipments necessary for testing & calibration during all tests. These instruments/equipments shall be of standard make with accuracy better than the accuracy expected from the calibrated/tested instruments & certified by National Physical Laboratory or other equivalent agencies.

(5) Inspection and testing shall be as per attached Inspection and Test Plan (ITP).

6 PROVEN TRACK RECORD

Vendor to provide Proven Track Record (PTR) for the offered gas detectors in similar applications with the quotation.
STANDARD SPECIFICATION

FOR

DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM
Abbreviations:

AC  Alternating Current
APC  Advanced Process Control
CFF  Common File Format
CPU  Central Processing System
CRT  Cathode Ray Tube
DA  Data Access
DC  Direct Current
DD  Device Description
DCS  Distributed Control System
DVD  Digital Versatile Disc
EDDL  Enhanced Device Descriptive Language
EPROM  Erasable Programmable Memory
EMI  Electromagnetic Interference
ESD  Emergency Shutdown System
FAT  Factory Acceptance Test
FDT / DTM  Field Device Tool / Device Tool Manager
FF  Foundation Fieldbus
FMEDA  Failure modes, Effects and Diagnostic Analysis
GPS  Global Position System
HART  Highly Addressable Remote Transducer
HDA  Historical Data Access
HI  Foundation Fieldbus low speed (31.25kbps) loop powered bus
HSE  High Speed Ethernet
HVAC  Heating, Ventilation and Air Conditioning
HW  Hardware
HWC  Hardware Console
I/O  Input / Output
IAMS  Instrument Asset Management System
LAN  Local Area Network
LAS  Link Active Scheduler
LCD  Liquid Crystal Diode
MCC  Motor Control Centre
MOV  Motor Operated Valve
MTTF  Mean Time to Failure
MTTR  Mean Time to Repair
OIS   Operator Interface System
OLE   Object Linking and Embedding
OPC   OLE for Process Control
PC    Personnel Computer
P&ID  Piping and Instrumentation Drawing
PID   Proportional, Integral and Derivative
PLC   Programmable Logic Controller
QUAD  Quadruplet
RAID  Redundant array of independent discs
RAM   Random Access Memory
RDBMS Relational Database Management System
RFI   Radio Frequency Interference
ROM   Read Only Memory
SAT   Site Acceptance Test
SCSI  Small Computer System Interface
SER   Sequence of Event Recorder
SIL   Safety Integrity Level
SIS   Safety Instrumented System
SPD   Surge Protection Device
SQL   Structured Query Language
TCP/IP Transmission Control Protocol / Internet Protocol
TFT   Thin Film Transistor
UHF   Ultra High Frequency
UPS   Uninterrupted Power Supply
USB   Universal Serial Bus
VDU   Video Display Unit
VFD   Vertical Field Device
VHF   Very High Frequency
WAN   Wide Area Network

Triple Modular redundant (TMR), Quadruple Modular Redundant (QMR) configuration, Flexible Modular Redundant (FMR) configuration, Virtual Modular Redundant (VMR)
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PART – I

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GENERAL

1.1 SCOPE

1.1.1 This specification, together with the data sheets attached herewith defines the minimum functional requirements for the design; hardware, software and firmware specifications, nameplate marking, testing and shipping of Distributed Control System designed for reliable effective and optimum control and monitoring of a process plant.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser’s enquiry:-

AG-181 Foundation Fieldbus System Engineering Guidelines
EN 10204 Inspection Documents for Metallic Products.
EN 50039 Intrinsically Safe Electrical System
IEC 60079 Electrical Apparatus for Explosive Gas Atmosphere.
IEC 60529 Degree of Production Provided by Enclosures.
IEC 60617 Graphic Symbols for Electronic Diagram
IEE 4 Guidelines for Documentation of Computer Software for Real time and Interactive Systems

FF – 569 Foundation Fieldbus Host interoperability support test procedure
FF – 816 Foundation Fieldbus Specification 31.25 Kbits/s Physical Layer Profile
FF – 890–894 Foundation Fieldbus Specification Function Block Application process

ANSI / ISA Security Technologies for Manufacturing and control system
TR 99.00.01

ANSI / ISA Integrating Electronic Security into the manufacturing and control systems environment
TR 99.00.02

EEMUA 191 Alarm System, a guide to design, management and procurement
IS-3043 Code of Practice for Earthing

IS 13947 Degree of Protection provided by Enclosures for low voltage switchgear and control gear

IS 13948 Flameproof Enclosures of Electrical Apparatus

ISA S 71.01 Environmental Conditions for process Management and Control System: Temperature and Humidity

S 71.04 Environmental Conditions for Process Measurement and control System: Airborne Contaminants

S 5.2 Binary Logic Diagrams for Process Operations
S 5.3 Graphic Symbols for Distributed Control System Display Instrumentation, Logic and Computer System.

S 5.4 Instrument Loop Diagram

S 5.5 Graphic Symbols for Process Display

S 18.1 Annunciator Sequences and Specifications

S 50.2 Fieldbus Standard for use in Industrial Control System


IEC-61000-4-4 Electromagnetic Capability (EMC) – Testing and measurement techniques – Electrical fast transients / burst immunity test

IEC-61000-4-5 Electromagnetic Compatibility (EMC) – Testing and Measurement techniques – Surge immunity test

IEC-61000-6-2 Electromagnetic Compatibility (EMC) – Generic Standards – Immunity for Industrial Environments

IEEE 472 Electrical Surge protection

IEC-60584 Thermocouple (Tolerances)

IEC-60751 Industrial Platinum Resistance Temperature Sensors

ANSI MC 96.1 Temperature Measurement Thermocouples


IEC 61131 Programmable Controllers

IEC 61511 Functional Safety – Instrumented System for Process Industry Sector

IEC 61158 Fieldbus Standard for use in Industrial Control Systems.

1.1.3 In the event of any conflict existing between this specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Design Basis / Statutory regulations

b) Data Sheets

c) Standard specifications
d) Codes and standards

1.1.4 In addition to meeting purchaser’s specifications in totality, vendor’s extent of responsibility shall also include the following:

a) Purchaser’s data sheet specify the minimum acceptable functional requirements for the control system. It shall be vendor’s responsibility to select proper hardware, software and firmware to meet the specified functional requirements.

b) Purchaser’s data sheets specify the scan time / cycle time / response time / macro cycle time and loading requirements. Vendor shall be responsible for sizing and selecting their standard product i.e. hardware, software and firmware to meet the requirements specified in the purchaser’s data sheets.

c) Selection of proper and adequate hardware, software and firmware to meet architectural requirements specified in the purchaser’s specifications, keeping the integrity of functional blocks specified in the configuration diagram attached with the material requisition.

d) Segment design based on requirements specified in the job specifications and its validation during site testing and pre-commissioning.

e) Adequacy of Bill of material selected to meet purchaser’s requirements. Vendor to note that bill of material shall not be verified by the purchaser during evaluation stage. Any hardware, software and firmware required to meet the purchaser’s specified requirements shall be provided by the vendor without any implication.

f) Providing adequate mandatory spares including consumable spares as specified in the purchaser’s specifications. Vendor shall be responsible to meet mandatory spare requirements specified by the purchaser.

1.2 Bids

1.2.1 Vendor’s quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition.

1.2.2 Whenever a detailed technical offer is required, vendor’s quotation shall include the following:

a) Compliance to the specifications.

b) Detailed specification sheets for each sub-system. The specification sheet shall provide information regarding hardware specifications, software specifications, redundancy requirements, capacity, power consumption etc. of the distributed control system and its accessories. The material specifications and unit of measurement for various items in vendor’s specification sheets shall be to the same standards as those indicated in purchaser’s data sheets.

c) System security features and design details
d) Proven references for each offered model in line with clause 1.2.4 of this specification whenever specifically indicated in the purchaser’s specifications.

e) A copy of approval for flameproof enclosure, intrinsic safety etc whenever specified, from local statutory authority, as applicable, like Petroleum and Explosive Safety Organisation (PESO) / Chief Controller of Explosives (CCE), Nagpur or Director General of Mines Safety (DGMS) in India along with;

   i) Test certificate from recognised house CIMFR (Central Institute of Mines & Fuel Research) / ERTL (Electronics Research and Test Laboratory) etc. for specified protection class as per relevant Indian Standard for all Indian manufactured equipments or for equipments requiring DGMS approval.

   ii) Certificate of conformity from agencies like LCIE, BASEAFA, PTB, CSA, UL etc., for compliance to ATEX or other recognised standards for all equipments manufactured outside India.

f) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason to deviate from the specified requirement, they must include a list of deviations item wise, summing up all the deviations from the purchaser’s data sheets and other technical specification along with the technical reasons for each of these deviations.

g) FMEDA report and calculations for probability of failure on demand to meet specified SIL requirements (e.g. SIL3).

h) Catalogues giving detailed technical specifications, model decoding details and other related information for each item / sub-system covered in the bid.

1.2.3 Vendor shall offer only their standard proven product i.e. hardware, system software and firmware, which shall be configured to meet the functional requirements specified in the material requisition. Whenever any bought out item is offered to meet the configurational requirements specified in the material requisition, it shall also meet the functional requirements. Moreover, the equipment being offered / supplied shall be of latest proven version available in the current manufacturing range and meeting the requirements specified in clause 1.2.4 of this standard specification.

1.2.4 The system hardware, software and firmware as offered, shall be field proven and should have been operating satisfactorily for a period of minimum 4000 hours continuously on the bid due date in the validly similar size and application specified in the purchaser’s data sheet. Items with prototype design or items not meeting provenness criteria specified above shall not be offered or supplied.
1.2.5 The detailed scope of work, specific job requirements, exclusions, deviations, additions etc. shall be indicated in the job specifications which shall be part of material requisition.

1.2.6 Whenever specified, vendor shall furnish tested values of failure rates, probability of failure on demand and test intervals for safety integrity level analysis.

1.2.7 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals shall be in English language only.

1.2.8 Vendor shall also quote for the following;

   a) Two year’s operational spares for each sub-system and their accessories which shall include the following as a minimum;
      i) All type of electronic modules e.g I/O modules, processor modules, communication modules, memory modules, disc controller module, power supply modules etc.
      ii) All type of auxiliary items e.g. barriers / isolators, hardwired instruments, annunciator modules, receiver switches, trip amplifiers, temperature element converters etc.
      iii) Switches, lamps, fuses, connectors, terminals, pre-fabricated cables, circuit breaker, relays etc.
      iv) Video display units, keyboards, disc drives, PC’s, network items (e.g. switches, hubs etc.) etc.

   b) Any special tools and test equipments needed for the maintenance of DCS, PLC’s and other items being offered by vendor. This shall also include test equipments for fieldbus testing and configuration like fieldbus tester, fieldbus configurator etc. wherever specified in the data sheets. Vendor must confirm in their offer if no special tools or test equipments are needed for maintenance other than those specifically indicated in purchaser's data sheet.

1.3 **Drawing and Data**

1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of producibles, prints and soft copies shall be dispatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design manuals, installation manual, operation and maintenance manual etc., submitted by the vendor after placement of purchase order shall include the following, as a minimum:
a) Specification sheet for each sub-system, auxiliary instrument and bought out item.
b) Certified drawings for complete system including:
   i) GA drawings for panels, cabinets, marshalling racks, hardwired consoles, operator / engineering console etc with complete dimensions details, internal construction and weight in kilograms.
   ii) Control room e.g. console room, rack room and engineering room layout with all dimensions in millimeters.
   iii) Channel base drawing for console room, rack room and engineering room.
   iv) Input / output assignment
   v) Fieldbus segment drawing
   vi) Loop wiring diagram
   vii) Power supply distribution single line diagram
   viii) Dynamic graphic diagrams
   ix) System grounding drawing
c) Design manuals and functional design specifications which shall include hardware design manual, software design manual and special software specifications.
d) Copy of type test certificates.
e) Copy of test certificates for all tests indicated in Part II of this specification.
f) Installation manual containing installation procedure for distributed control system and other items covered in the material requisition.
g) Power-on, start-up and internal testing procedures.
h) Software debugging and system configuration procedures
i) Calibration and maintenance manual containing maintenance procedures including replacement of parts, application modification etc.
j) Any other drawings and documents specifically indicated in job vendor data requirement enclosed with the material requisition.
2.0 DEFINITIONS

The various terms used in this specification are defined as follows:

2.1 Distributed control system

The class of control systems which in addition to maintaining and managing data bases in distributed fashion also executes the stated control functions and permits transmission of control, measurement and operating information to and from a single or a plurality of user specified locations connected via a communication sub-system.

2.2 Programmable Logic Controller

The class of control systems which can be programmed to execute plant shutdown and / or interlock / sequence logics to the specified safety integrity levels.

2.3 Accessible

A system feature that is viewable by and interactive with the operator and allows the operator to perform user permissible control action e.g. set point change, auto-manual transfers or on-off actions.

2.4 Assignable

A system feature that permits an operator to direct a signal from one device to another without the need for change in wiring, either by means of switches or via other data entry devices like key board commands to the system.

2.5 Configurable

A system feature that permits selection through entry of key board commands or commands from other data entry devices of basic structure and characteristics of a device or system, such as control algorithm, display format or I/O termination.

2.6 I/O

Input / Output with respect to process / operator.

2.7 Fieldbus

Fieldbus is a digital two-way multi drop communications link among intelligent measurement and control devices.

2.8 System Size


System size shall be defined as maximum number of process inputs or tags those can be connected to the system and viewable from any one of the VDUs of an operating console in all hierarchical displays without changing the configuration or without operator interaction considering;

a) all inputs as close loops
b) all inputs as open loops

2.9 Operator console

Operator console is the operator’s main plant interface device via which operator can view, monitor and control the plant and can give instructions to peripherals to execute commands, and shall have protective access to configure and maintain the system.

2.10 Engineering console

Engineering console shall be the engineer’s main interface device via which engineer can configure and maintain the system, and shall have protective access to monitor and control the plant, give instructions to peripherals to execute commands.

2.11 Local Level

All those sub-systems, which directly interface with field devices shall be referred to as local level.

2.12 Central Level

Operator consoles and Engineering Console, which present data acquired from local level devices shall be referred as Central Level.

2.13 Database

Database shall be defined as the information stored temporarily or permanently in the system which can be accessed by various programs to meet all its functional requirements.

2.14 Global Database

Global database is defined as the database that can be accessed by two or more non-nested modules of a program without being explicitly passed as parameters between the modules.

2.15 Loop integrity

A system shall be said to have loop integrity if the failure of one component in the system/ sub-system does not affect more than one loop.

2.16 Interchangeability

System/sub-systems shall be said to have full interchangeability if the functions and information available on one system/sub-system shall also be available on the other in totality.

2.17 System Loading
System loading for a sub-station is defined as the percentage of time a sub-system spends in carrying out various activities referred to the use of memory, CPU time and communication capacity in the worst case of high sub-system operation out of the designed / designated cycle time of the sub-system.

2.18 **Bus-degradation**

Bus-degradation shall be defined as a change in the system performance from the specified one measured in terms of display update rate while loading the communication sub-system from 10 through 100 percent.

2.19 **Redundancy**

A system component shall be termed as redundant if it takes over automatically the operation in the event of the failure of the main component without causing any interruption in the system and upsetting the process. The repaired or replaced device shall be brought in-line only through operator action without upsetting system operation.

2.20 **Switchover Time**

Time required for a back up instrument / system to come on-line automatically in case of the failure of the main instrument / system.

2.21 **Processor Cycle Time (Tpc)**

Processor cycle time is the measure of the processing speed of a processor and is user selectable from the pre-defined discrete values. Processor cycle time for a sub-systems shall be defined as follows:-

a) **Controller Sub-system**

Processor cycle time for controller sub-system shall be defined as the total time taken by the control processor to read inputs supplied by input module, execute control algorithm and write the outputs for the output module.

b) **Data acquisition sub-system**

Processor cycle time for data acquisition sub-system shall be defined as the total time taken by the processor to read inputs supplied by input processor, perform calculations for all the open loops configured within the data acquisition sub-system and make data available to the communication sub-system.

c) **Programmable logic controller**
Processor cycle time for programmable logic controller shall be defined as the total time taken by the processor to read input supplied by input module, execute all computations (analog as well as logic as configured) and write the outputs for the output module.

2.22 Scan time (ts)
Scan time is the end-to-end response time of a sub-system and shall be defined as follows:
For fieldbus based system refer clause 2.25 for close loop response time.

a) Close-Loops
Scan time for a close-loop shall be defined as the total time taken by a sub-system e.g. controller and data acquisition sub-system to read inputs from the input terminal, process input, perform control algorithms, update control output and write output at the output terminal for all the loops configured within the sub-system.

b) Open-Loops
Scan time for an open loop shall be defined as the total time taken by a sub-system e.g. controller and data acquisition sub-system to read input from input terminal, process input, perform calculations and write output for communication sub-system to pick-up the same for all the open loops configured within the sub-system e.g. controller and data acquisition sub-system.

c) Logic Loops
The scan time for a logic loop shall be defined as the total time taken by a sub-system e.g. programmable logic controller to read input from the input terminal, process input, execute logic, updating logic output and write output at the output terminal for all the logics configured within the subsystem.

2.23 Control Cycle time
Control cycle time is defined as the total cycle time taken by the supervisory computer to read data from control system, perform calculations and update the set point of a regulatory loop configured in the control system e.g. controller and data acquisition sub-system.

2.24 Macro Cycle
Macro cycle is defined as a single iteration of a schedule within a fieldbus device.

2.25 Macro Cycle Time
Macro Cycle time or execution time is defined as the amount of time taken by a fieldbus device to complete the macro cycle. Macro cycle time can refer to a single field device, the LAS or a complete segment made up of multiple devices.
2.26 Loop Response Time

Loop response time for fieldbus based system shall be defined as the total time required to perform the following functions in each of the specified loop configuration;

a) Control function in transmitter

Execute the analog input and control (PID) function block in transmitter, publish the output on the fieldbus, receive the controller out value and perform analog output function block in final control element.

b) Control function in final control element

Execute the analog input function block in the transmitter, publish the process variable on the fieldbus, receive the process variable and execute the control algorithm (PID) and analog output function block in the final control element.

c) Control Function in DCS

Execute the analog input function block in the transmitter, publish the process variable at DCS, execute the control algorithm (PID) in DCS, publish the controller output value on the fieldbus and execute the analog output function block in the final control element.

2.27 Display update rate

Display update rate shall be defined as the time taken by the system to display the information present at the system input terminals updated on the current display on the VDU of an operator console.

2.28 Call-up time

Call up time shall be defined as the time taken by the system to display a particular display/data on the VDU after getting the corresponding command from the operator.

2.29 User’s memory

Free memory space available after utilisation of memory required for system operation, configuration and implementation of application and other system related functions for implementation of user defined specific programs such as plant calculations, process optimization or MIS (like free formatting of certain logs). The programs shall either be written in high level language or system specific language.

2.30 Event
An event shall be defined as any action taken by the operator via operator keyboard or switches on hardwired console like change of set point, change of control mode, start/stop of motor, open/close of shut down valves, alarm acknowledge etc.

2.31 Sequence of Event (SOE)
Arranging events in the sequence of their occurrence in time with a specified time resolution by a program is defined as sequence of event.

2.32 Sequence of Event Recorder (SOR)
System of sub-system which presents and / or records the events in the sequence of their occurrence in time with a specified time resolution utilizing its hardware and software capabilities is termed as sequence of event recorder.

2.33 Real time trend
Real time trend shall be defined as a continuously progressing graphical record showing continuously updated parameter with most recent value and a past record of minimum of 10 minutes without depressing any additional key for moving backward in time.

2.34 Windowing
Ability of software program to break the console screen i.e. video display unit into simultaneous or overlapping zones with separate presentations at the same time.

2.35 Interoperability
Interoperability is the capability to substitute a device from one manufacturer with that of another manufacturer as a fieldbus network without loss of any functionality or degree of integration.

2.36 Acyclic Period
Acyclic period is defined as the portion of communication cycle time during which information other than publish / subscribe data is transmitted.

2.37 Capabilities File
A capabilities file describes the communication objects in a fieldbus device. A configuration file can use DD files and capabilities files to configure a fieldbus system without having the fieldbus device active.

2.38 Link Active Scheduler (LAS)
LAS is defined as a deterministic centralised bus scheduler that maintains a list of transmission times for all data buffers in all devices that need to be cyclically transmitted.
2.39 Link Master
Any device containing the link active scheduler personality that can control communication of a H1 fieldbus segment is designated as link master.

2.40 Segment
Segment is defined as a network or part of network that serves as the primary communication highway for the connected field-bus devices.

2.41 Resource Block (RB)
Resource block describes the characteristics of a fieldbus device such as device name, manufacturer and its serial number. Resource block is unique for a device.

2.42 Vertical Communication Relationship (VCR)
VCR is defined as the pre-configured application layer channels which provide the data transfer between applications. Publisher – subscriber, client – server and report distribution are three VCRs in foundation fieldbus.

2.43 Link Objects
Link object contains information to link function block input / output parameters in the same device and between different devices.

2.44 Plant Control Network
Communication network within a plant that has control information circulating between various plant units or processing locations.

2.45 Plant Information Network
High-level communication network which serves various user’s within a plant and transfer information for the purpose of unit / plant monitoring. This network is different than control network and is generally realised using open communication protocol network e.g. OPC etc.

2.46 OPC node
OPC node is any node in the network that provides OPC interfaces consistent with OPC data access, OPC alarm and event and OPC historical data access interface specifications certified against OPC compliance and interoperability test specification.

2.47 Computer Integrated Manufacturing (CIM)
Computer integrated manufacturing shall be defined as the integration of process, plant and business operations made possible through information network.

3.0 SPARES PHILOSOPHY
3.1 The system including programmable logic controller, alarm information management system, sequence of event recorder, hardwired instruments etc. shall meet the following spare philosophy. Th is
philosophy shall also be applicable for items like field-bus accessories, barriers, relays, terminals, lamps, push buttons etc.

3.1.1 Mandatory Spares

Vendor shall include following mandatory spares in their scope of supply;

3.1.1.1 Installed Engineering Spares

Installed engineering spares shall be provided in each sub-system for each type of module to enhance the specified system functional requirements by 20%. The basic of offering installed engineering spares shall include;

a) For a system with conventional and / or smart input / output, 20% spare input / output of each type shall be considered for calculating I/O modules and all other related accessories.

b) For a system with fieldbus input / output, 20% spare segments of each type of field-bus type (foundation fieldbus, profibus etc.) shall be considered for calculating I/O modules, power supply modules and all other related accessories. When only input / outputs are indicated instead of field-bus segments, the installed spare philosophy as specified in 3.1.1.1 (a) shall be followed.

c) For all serial input / outputs to the system 20% spare serial I/O channels of each type of serial input / output shall be provided.

d) A minimum of one spare I/O module of each type as offered to meet type of inputs / outputs specified in the material requisition.

e) 20% spare accessories like relays, switches, lamps, fuses, circuit breakers, barriers, isolators, terminals etc.

f) A minimum of one number of input / output module and accessories of, each type such as analog input / output, discrete (contact) input / output, pulse input, serial input / output, foundation fieldbus / profibus PA input / output modules (in case of fieldbus based system) temperature input shall be provided irrespective of those required as per 3.1.1.1(d) as engineering spare.

g) The engineering spares shall be wired up to the field cable interface and shall be in ready-to-operate condition when field cable is connected to spare assigned terminals.

h) Spare pairs of the incoming cables shall be terminated on spare terminals in the marshalling / barrier cabinets as applicable.

i) The system shall be fully engineered considering 20% installed engineering spares
including processor loading.

3.1.1.2 **Spare Space Requirement**

In addition to installed engineering spares specified in Clause 3.1.1.1 of this specification, the system shall be provided with following spare space;

a) The controller and data acquisition racks shall have 10% usable spare space for installing additional I/O and field-bus segment modules in future. However, the control and data acquisition processor shall have additional 10% capacity to handle these I/O’s and field-bus segment. In addition, internal wiring for the same shall be completed up to I/O terminals.

b) Each operator console shall contain 10% usable spare group and related display capability in addition to as specified in para 3.1.1.1 of this specification.

c) The system shall have capability to extend its historical trending, logging and user’s memory by 20% to meet future expansion with/without adding additional memory modules.

d) I/O racks of programmable logic controller shall have 10% usable spare space for installing additional I/O cards of each type in future. However internal wiring for the same shall be connected up to the I/O terminals.

e) Processor system of programmable logic controller shall have capability to execute additional 20% logics.

f) The communication sub-system shall have sufficient capacity to handle additional data contributed by addition of 20% I/O / segments over and above installed engineering spares.

g) Usable spare space in panels and cabinets to install 10% spare hardwired items like barriers, trip amplifiers, receiver switches, panel mounted instrument, relays etc. in future.

3.1.1.3 **Spare Memory Requirement**

a) The system shall be provided with a minimum of 40% spare memory capacity, as required for application program and data base to meet specified functional requirements.

b) For field-bus based system, spare memory capacity (and CPU loading) shall be calculated considering all control algorithms being configured in the system and executed at the scan time equal to the specified control loop response time.

c) It shall be possible to extend the memory by at least 20% over and above the actual requirement at a later date.

3.1.1.4 **Spare Software Capability**
a) Sufficient additional software capacity shall be available in the system to take care of spares requirement as specified in para 3.1.1.1 and 3.1.1.2(a) to (f) of this specification to meet all functional requirements as per para 5.0 of this specification.

b) Unless specifically indicated otherwise, the offered system shall have software licenses to cover all the tag numbers indicated in the material requisition, including installed engineering spares and spare space indicated in clause 3.1.1.1 and 3.1.1.2 of this specification.

3.1.1.5 Predefined Mandatory Spares

a) Mandatory spares shall be ware house spares and shall be supplied as loose items.

b) Mandatory spare module of 5% or one module of each type, whichever is higher, must be supplied for each type of modules being used including in consoles.

e) For items like hardwired instruments, assignable recorders, Personnel computers, VDU / video screens, keyboards, disc drives, RAID controller, lamps, network components, barriers, fuses and circuit breakers complete item limited to 5% or minimum one of each type shall be supplied as predefined mandatory spare. But this shall not include hardware like discs, terminals, switches, telephone sets etc.

d) Items like personnel computers, operator consoles servers, engineering consoles etc. where complete item needs replacement instead of individual modules, complete unit shall be supplied as mandatory spares in line with clause 3.1.1.5(b).

e) Software which need to be separately loaded in the items specified in clause 3.1.1.5(d) above to define the items personality and can't be uploaded from engineering console or any other network device shall be supplied along with additional software.

3.1.1.6 Consumable Spares

Any paper, ribbon, printer heads and ink required for printers, assignable recorders, video copier or any other consumable item shall be supplied along with system required for minimum of six months duration after system acceptance.

3.1.1.7 Commissioning Spares

Unless otherwise specified, vendor shall be responsible to supply all spares which are found necessary to replace failed modules, failed sub-systems, or corrupted / faulty softwares while performing pre-commissioning and commissioning activities.

3.1.2 Two years operational spares
Two years operational spares shall be as per Clause 1.2.8(a) of this specification and shall be quoted separately.

4.0  SYSTEM CONFIGURATION

The system configuration shall consist of the following major sub-systems:-

4.1  Controller and Data acquisition sub-system

Controller and data acquisition sub-system is the main field interface sub-system and is capable of performing control and data acquisition functions as an integrated sub-system.

Controller and data acquisition sub-system shall interface with field instrumentation like transmitters, process switches and final control elements to monitor and/or control process parameters like flow, temperature, level etc. The sub-system shall include a comprehensive set of control algorithms and auxiliaries to provide close loop control and data monitoring capability of the system.

4.2  Operator interface sub-system

Operator interface sub-system shall consist of one or more operator consoles for monitoring and controlling process parameters and performing other process related functions.

4.3  Communication sub-system

Communication sub-system interconnects various sub-systems over which they can communicate with each other to meet all functional requirements.

4.4  Engineer interface sub-system

Engineer interface sub-system shall consist of an engineering console primarily for tuning, configuring and maintaining the system.

4.5  Supervisory computer sub-system

Supervisory computer, when specified, shall be employed for providing supervisory level plant control, plant and unit optimization and other computer based plant management capabilities. For the Integrated network, each node where history resides should be minimum RAID-5 configuration to ensure maximum availability of history or otherwise separate redundant Servers in RAID-5 configuration and redundant power supply configuration should be provided.

4.6  Programmable Logic Controller

Plant start up and safety shut-downs shall be performed by separate programmable logic controller which shall communicate with other sub-systems over the communication sub-system.
4.7 Foreign Device Interface

Foreign Device like programmable logic controllers, gas chromatographs, analyzer systems, gas turbine systems etc. when specified shall communicate with other subsystems over the communication sub-system for plant monitoring and control using foreign device interface. The foreign device interface shall be either dedicated or shall be part of controller data acquisition sub-system as specified in the job requirements.

4.8 OPC Server

OPC Server when specified in this specification is used as synonymous with any server entity on the communication sub-system network which shall allow the user to implement applications, within or outside the system, without providing any special drivers or custom interfaces. OPC server, when specified, shall be used to transfer / receive data to / from applications run in other systems.

4.9 Unit History Node

4.9.1 Unit history node, when specified, shall store the long term historical data of the complete unit and shall interact with central computer system over plant wide network. In addition every history residing node should be minimum RAID-5 configuration.

4.9.2 Unit history modem, when specified shall be a dedicated node and shall be in addition to historical data required for normal plant operation (specified as part of operating interface sub-system).

4.10 Sequence of Event Recorder (SER)

Sequence of event recorder, when specified, shall be a dedicated equipment which shall identify, store and print alarms with the specified time resolution. SER may also transfer data to operator sub-system over communication sub-system.

4.11 Documentation node (DON)

Documentation node, when specified, shall be a node on the information network sub-system and shall store unit documentation.

4.12 Alarm Information and Management Sub-system (AIMS)
Alarm information and management sub-system when specified, shall be a alarm management package which shall gather alarm information from various sub-systems and shall present the desired meaningful analysed data for information and further analysis.

4.13 Instrument Asset Management System (IAMS)
Instrument asset management sub-system shall acquire store, analysed and present meaningful diagnostic and maintenance related data of field devices for efficient plant maintenance.

4.14 Large Display System (LDS)
Large Display System, when specified, shall consist of one or more large video screens which shall display either operator selected operator console screen or any pre-selected screen on a back projected large video screens as real time basis.

4.15 Hardwired Instrumentation
Hardwired instrumentation shall be provided as a back up to the distributed control system for critical process parameters when specified in the job specification.

4.16 Information Network Sub-system
4.16.1 Information network when specified shall interconnect with various plant wide systems like distributed control system/systems, mainframe computers, personal computers, laboratory information and management system (LIMS) etc over which any information can be exchanged without affecting and disturbing the plant control and operations.

5.0 DESIGN AND CONSTRUCTION

5.1 Design Requirements
5.1.1 The system shall be microprocessor based having functional distribution and data base distribution sub-system wise. The system design shall ensure that;
   a) All the functions defined in this specifications are performed in an integrated manner
   b) The access to the distributed data base is available system-wide.

This system shall also have networking capability with other systems distributed geographically in the various units of a plant, over a plant wide information network such as Ethernet or other industrially recognised open networks.

5.1.2 The system shall be of modular construction and expandable in future by adding additional modules. The type of modules shall be kept to the minimum possible in order to have interchangeability and low inventory.
5.1.3 System Availability
a) The system shall be designed ‘fault avoidant’ as a minimum by selecting high grade components of proven quality and proper design of system electronics.
   Redundancy shall be provided, as per this specification as a minimum, to improve the system availability and reliability. Due considerations shall be given to the environmental conditions particularly for field mounted sub-system, if specified in job specifications, during system design.
b) The system shall have a high MTBF value and shall have well proven record of operating in hydrocarbon plants.
c) The system shall be designed with 99.995% or greater availability. The availability shall be defined as follows;

   \[
   \text{Availability} = \frac{\text{Meantime Between Failure (MTTF)}}{\text{MTTF} + \text{Mean time to repair (MTTR)}}
   \]

   For the purpose of calculations, consider mean time between repairs as four (4) hours unless the manufacturer recommends higher value for MTTR. It is therefore necessary that;

   i) Vendor covers all necessary spare parts in 2 years recommended operational spares which shall be necessary to meet specified MTTR time.

   ii) Vendor provides adequate training to owner's personnel and cover all necessary maintenance related topics in their training programmes to ensure specified MTTR time.

5.1.4 Operating Environmental Conditions
5.1.4.1 Environmentally controlled location installation
a) All subsystem of Distributed Control System located in control room, Local Control Room or in Satellite Rack room shall be able to operate satisfactorily from 15°C to 30°C and 20% to 80% non condensing humidity.
b) In addition to above, all such sub-systems shall also be able to operate satisfactorily in case of air conditioning failure with ambient temperature of 50°C and 90% non-condensing humidity until the system safe operating limits are exceeded. The minimum period of continuous operation shall be 48 hours at least once in a month without any damage or degradation of system performance. Vendor, therefore, shall provide continuous temperature monitoring for each enclosed cabinet housing items / equipments generating heat, such as system cabinets, barrier cabinets, relay cabinets etc and also provide alarm for operator
alert in case the safe operating temperature limits are exceeded. Alarm in the operator consoles shall be available for each cabinet while group alarms shall be provided on hard-wired annunciator located on hardware console.

c) Chemical filters have been provided in the incoming air conditioning air to limit the concentration of contaminants below following limits

<table>
<thead>
<tr>
<th>Contaminants (Corrosive Gases)</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOx</td>
<td>&lt;10ppb</td>
</tr>
<tr>
<td>Nox</td>
<td>&lt;5ppb</td>
</tr>
<tr>
<td>H2S</td>
<td>&lt;5ppb</td>
</tr>
<tr>
<td>Cl2</td>
<td>&lt;10ppb</td>
</tr>
<tr>
<td>SPM</td>
<td>&lt;0.2gm/m3</td>
</tr>
</tbody>
</table>

All sub-systems and system components shall be suitable for operating continuously in the above mentioned corrosive environments.

d) Vendor shall provide continuous corrosion monitoring system consisting of transmitter with 4 – 20mA output and switch unit with setting as per contaminant level exceeding limits specified in clause 5.1.4.1(c) of this specification. Unless otherwise specified the number of corrosion monitors shall be as follows;

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Room Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosion Transmitter</td>
<td>Rack Room / Satellite</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>Rack Room</td>
<td></td>
</tr>
<tr>
<td>Corrosion Switch Unit</td>
<td>Rack Room / Satellite</td>
<td>3 Nos.</td>
</tr>
<tr>
<td></td>
<td>Rack Room</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Console Room</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>Engineering Room</td>
<td>1 No.</td>
</tr>
</tbody>
</table>

Continuous corrosion monitoring trend and alarms shall be provided on the operator console while one group alarm shall be provided on the hard-wired annunciator located on the hard-wired console.

5.1.4.2 Outdoor Installations

a) Sub-systems or system components which are installed outdoor shall be able to continuously operate at ambient temperature of 50°C and non-condensing humidity of 90%.
b) Unless otherwise specified, all sub-systems or system components installed outdoor shall have corrosive environmental protection coating meeting the environmental classification class G3 as per ISA-S71.04.

5.1.5 Transient, Static and EMI / RFI Protection

5.1.5.1 The system shall be internally protected against system errors and hard ware damage resulting from:

a) Electrical transients on power wiring
b) Electrical transients on signal wiring
c) Connecting and disconnecting devices or removing or inserting printed circuit boards in the Distributed Control System(DCS) and Programmable Logic Controller (PLC).

5.1.5.2 All sub-systems and system components shall be capable of accepting various signal inputs for its direct use while preventing noise errors due to electromagnetic interference (EMI) or radio frequency interference (RFI) including nearby radio stations, hand held two way radios, electrical storms, solenoids, relays or contactors carrying heavy currents as per levels of Environmental electromagnetic phenomenon defined in IEC-61000-6-2. The system shall have total noise immunity from UHF / VHF radio communication equipments (RFI) and (EMI) noise generating equipments as per IEC-61000-4. The surge withstand capability for input/output modules shall be as per IEEE standard 472.

5.1.5.3 System cables for interplant, inter unit, and others routed in the field, the level of surge immunity required for equipment signal ports shall be increased to level 4 as defined in IEC-61000-4-5 and the system shall operate according to performance criterion B as defined in IEC-61000-6-2.

5.1.6 On-line replacement

5.1.6.1 On-line replacement of electronic module shall be possible in such a way that removal and addition of an I/O module shall be possible and safe without de-energising the system. Furthermore, there shall not be any interruption of the system while replacing a faulty module wherever redundant modules are provided.

5.1.6.2 Apart from system modules, power supply units shall be replaceable on-line without disrupting the process and without effecting the system redundancies.

5.1.7 Electrical Isolation

Galvanic or optical isolation shall be provided for all field signals. The isolation levels shall be as follows;

| Analog I/o channel to system ground | : 1500 VAC |
| Discrete I/o channel to system ground | : 500 VAC |

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Isolation shall also be provided between Engineering / operator console/PLC programming terminal and related sub-systems connected to it if there is any possibility of high voltage being transmitted to the sub-systems.

5.1.8 Design Requirements of Equipments in Hazardous Area

5.1.8.1 Unless specifically indicated, the field devices are beyond the scope of this specification. However vendor shall be fully responsible for integrating these devices with their system including compiling and maintaining the engineering data base of these devices and incorporating the data base into the Asset Management System.

5.1.8.2 General Requirements

a) Unless otherwise specified, all instruments in hazardous area shall be intrinsically safe type. Other concepts shall be used when specified.

b) For conventional instrumentation, entity concept shall be used for selecting proper barriers / isolators.

c) Fieldbus segment in classified area may consist only of the type and number of devices which will not cause the segment current draw to exceed the rated barrier / isolator parameters.

5.1.8.3 Fieldbus design in Hazardous Area

The segment design and equipment solution shall be based on the classified area concept used. The functions and entity / safety parameters of power conditioner, safety barriers / isolator, terminators and field devices shall be considered to verify the compliance to the requirements applicable for the specified concept. Following concepts shall be used depending upon the one specified in the job specifications;

a) Entity Concept

Certified entity / safety parameters of each device shall be used to match the entity parameters on entity concept.

b) FISCO

Certified FISCO parameters shall be used and shall be matched like entity parameters. All elements in the hazardous area and their interface module shall be certified FISCO.

c) FNICO

Certified FNICO parameters and equipment shall be used to design loop on the basis of FNICO.

d) Multi barriers

The safety barriers / isolators shall be installed in the field in an increased safety enclosure. The enclosure shall be metallic either of SS or of anodised alluminium. The entity / safety parameters shall be matched as in case of entity concept. Vendor's scope shall include barriers duly installed in the box / junction box.
5.1.9 Repeat Signals

5.1.9.1 Unless otherwise specified in the job specifications, following philosophy shall be followed for repeat signals;

a) Whenever repeat contact outputs are required as per job specifications following philosophy shall be followed;

i) For intrinsically safe input contacts, isolating barrier with dual contact output shall be utilized.

ii) For all other contact inputs, repeat contact shall be provided using electro magnetic relays.

b) Whenever repeat analogue outputs are required as per job specifications, following philosophy shall be followed;

i) For intrinsically safe analogue inputs, isolating barrier with dual analogue outputs shall be utilized.

ii) For all other analogue inputs, repeat analogue outputs shall be provided using signal isolators with dual output.

5.1.10 System Integration

The distributed control system shall be a fully integrated control system, also the BMS system, STG PLC, MMS system and the Fire and Gas system should be fully integrated with the control system. Shut Down system and Fire and Gas system should not be integrated with the control system as or with serial/Foreign/third party device card, however engineering database and engineering tool of all the above three system should be separate, dedicated and independent of each other. Foreign devices like analyser system, third party equipment, (like compressors etc) etc. shall be functionally integrated with the distributed control system. Functionally integrated system shall meet the following requirements, as a minimum;

a) The foreign devices shall either be configurable from DCS engineering consoles or from the dedicated engineering consoles of each foreign device.

b) Unless specifically indicated otherwise, each foreign device shall be integrated with DCS through MODBUS (RTU) protocol using redundant interface unit.

c) Operator console shall display information in the similar fashion irrespective of source of information. Source of information shall be transparent to the operator.
d) The process alarms and diagnostic alarms shall be presented on the operator console in the similar fashion as DCS alarms.

e) Whenever specifically indicated, the time of all foreign devices shall be synchronized with DCS clock or GPS, as specified in the job specification.

f) The data transfer to and fro from other distributed control systems or supervisory computers through information network shall utilize OPC protocol with adequate security.

5.1.11 Surge Protection

5.1.11.1 Surge protection devices (SPD’s) shall be provided on the system to limit the surge voltages reaching beyond the safe limits, under normal, abnormal or lightening strike condition. Unless otherwise specified, SPD's shall be provided at least at the following locations;

a) All serial signal cables (UTP / STP / coaxial and not fibre optical) going from or to control system and from one location to another outside the control building at both ends.

b) All fieldbus segments at control system end.

c) All power incoming cable (220 V AC) UPS or non UPS, at the power supply distribution cabinet.

5.1.11.2 The selection of type and rating of SPD shall be selected such that the introduction of this device shall not change the characteristics or reliability of an application, whether it is for the protection of power system, signal such as fieldbus or analog or communication signal, as applicable.

In case of fieldbus system, the SPR shall be selected such that its inclusion in the segment shall not degrade the fieldbus signal, maximum length of the segment and/or number of devices on a segment significantly.

5.1.12 System Securities

5.1.12.1 The system shall have incorporated a fool proof system security feature in its design which would protect its database and functioning against viruses, trojans and works through integrated anti virus, fire wall and intrusion detection for the system.

5.1.12.2 All devices and/or servers which interface and interact with external application must be supplied with hardware and software firewalls.

5.1.12.3 All the security protections, hardware or software, as offered shall provide protection against all sort of threats and vulnerabilities which include;

a) Positive user authentication and login privileges.

b) Prevention of importation of viruses.

c) Packet filtering, content filtering, URL filtering protocol filtering and application level filtering to accept only intended data.

d) Strict Access controls like password hash files, cryptographic material used in confidentiality etc.
e) Hardening of operating system.

f) Firewall proxy.

g) Network sniffer and file integrity checkers

h) Scanning, enumeration and vulnerability scanning tools.

i) Log file analysis tools.

The functionalities indicated above are the indicative security features and shall be provided within and where data import / export utilities apply.

5.1.13 System Software

5.1.13.1 The system software shall be governed by the operating system running in a real time mode and shall be able to meet all functional requirements specified in clause 5.2 of this specification as a minimum. Any other standard/special software package, if available, shall also be offered describing the full capabilities.

5.1.13.2 The operating system and other standard softwares (e.g. OPC foundation fieldbus etc.) shall be of latest version.

5.1.14 The system shall have the capability of detecting the open sensors and short sensor. The sensor status reading on failure either upscale or downscale shall be field configurable.

5.1.15 Emergency Switches (ESD Switches)

5.1.15.1 All Emergency (ESD) switches shall be hardwired and shall preferably pull type with red coloured knob. Control room mounted ESD switches shall be installed on hardwired console.

5.1.15.2 ESD switches shall directly trip the final ESD element without any intermediate device. Where multiplication of ESD switch contacts is necessary fail safe relays shall be utilized (SIL3).

5.1.15.3 In addition to utilizing contacts for direct shutdown, the contacts shall also be used in ESD system (PLC etc) for logic implementation and event history.

5.1.16 Alarm by-pass Switches

5.1.16.1 Startup by-pass (SBS) switches

a) Unless otherwise specified, all SBS's shall be configured in the BMS system (i.e. PLC) and shall be operable from DCS operator console and PLC operator console when specified. All such by-pass switches shall be alarmed and shall have audit trail.

5.1.16.2 Maintenance by-pass switches (MBS's)

Unless otherwise specified, following philosophy shall be utilized for MBS's;
a) All process inputs shall have miniature back lighted MBS (else shall have LED to show by-pass status).

b) MBS shall be installed in a cabinet which can be physically lockable. The by-pass status shall also be available in operator console with a common flashing message always appearing on operator server whenever an MBS is operated. All MBS's shall have audit trail.

c) Logic-wise common alarm shall also be available on the hardwired console.

5.1.17 Interface with Electrical Input / Outputs

5.1.17.1 All contact input and output contacts from electrical switch gear panels (MCC / PCC etc.) shall be terminated in a dedicated 'Electrical Interface marshalling cabinet' located in control room. All such I/O's shall have intermediate relays.

5.1.17.2 Remote I/O rack shall be provided in sub-station for non-shutdown related data, when specifically indicated in the material requisition.

5.1.17.3 All serial I/O cables from sub-station to control room shall be redundant including remote I/O cable.

5.1.18 Automatic Loop Tuning Software Package

5.1.18.1 It shall be possible to tune a control loop or group of control loops on selective basis at a time automatically unless otherwise specified. Tuning parameters computed by the system shall either be loaded automatically or manually by operator.

5.1.18.2 The automatic loop tuning software shall be used to tune PID control loops. The auto tuning technology used shall utilize principles like Ziegler – Nichols, Cohen – coon or Internal Model Control (IMC).

5.1.18.3 The software package for loop tuning may reside / run on any system hardware including controller sub system, console sub system, engineering sub system, supervisory computer etc. The tuning software must ensure that the process is not disturbed whenever a loop is being tuned.

5.1.18.4 Automatic loop tuning package shall be able to study the dynamics of control loops and shall be able to compute response time, dead time, lead or lag time etc. directly from Engineering / operator console.

5.1.19 The system shall be suitable for power supply as specified in para 6.2 of this specification. Suitable battery back-up shall be provided for volatile memory protection only.

5.1.20 System Upgrade Capability

5.1.20.1 System shall be scalable and upgradeable by adding additional hardware, over and above the spares specified, without rendering the initial hardware and software investment obsolete within the capability of the system.

5.1.20.2 This is in addition to the system upgrades, hardware and software, available from vendor as standard from time to time.
5.1.21 Noise Level

5.1.21.1 Noise level generated by any equipment shall not exceed the following limits;

a) Noise level shall not exceed 55dBA for equipments installed in console room, engineering room and computer room.

b) Noise level shall not exceed 65dBA for equipments installed in rack room and satellite rack room (SRR).

c) For control rooms where consoles and cabinets are installed in the same room, the noise level generated by any equipment shall not exceed 55dBA.

5.1.21.2 The noise level shall be measured in dBA at a distance of 1 metre from the equipment generating noise.

5.1.22 Equipment Identification

Unless otherwise specified, all equipments shall be identified by tag numbers indicated in the data sheet / summary sheet attached with the material requisition. The tag number shall be inscribed on a nameplate which shall be fixed with screws. The nameplate shall be black laminated plastic with core i.e. black with white characters. The size and description shall be subject to purchaser's approval.

5.1.23 System Furniture

All system furniture required for mounting and operation of the system including mounting of tabletop equipments shall be supplied. Furniture for operating personnel shall be as defined in job specifications.

5.2 Functional requirements

5.2.1 The system, as a minimum, shall meet the following requirements without the supervisory computer:

a) Control
b) Data acquisition & monitoring
c) Alarming
d) Logging & report generation
e) Historical data storage
f) Trending
g) System shall have some free memory space available for the user and CPU shall have the additional capability to perform advance control functions, process optimization programs or
generate management reports as specified in job specification in addition to space requirements as per para 3.0 of this specification. The availability of process control language shall be preferred.

h) System shall support functionalities like remote calibration, remote diagnostics and asset management in case of smart or field-bus based instruments.

5.2.2 In addition to above, following functional requirements shall also be complied, when specifically indicated in the job specifications;

a) Sequence of event function.
b) Alarm management
c) Long term historisation
d) Open system connectivity

5.2.3 The system when specified with Programmable Logic Controller (PLC) either as integral part of system or as separate third party device it shall perform follow functions;

a) Process interlocks
b) Plant safety shutdown
c) Monitoring the sequence control units, when specified

Plant process and safety shutdown shall be independently performed by programmable logic controller. (PLC shall be communicating with other sub-systems via communication sub-system).

5.2.4 The system when specified along with a supervisory computer, shall meet the following requirements in addition to as specified in para 5.2.1 of this specification.

a) Advanced Control
b) Unit and plant optimization
c) Management information service reports.

5.2.5 Whenever information network along with plant wide interconnectivity is specified, the system shall meet any or all of the following requirements in addition to those specified in para 5.2.1 of this specification as specified in the material requisition:-

a) Centralised information system
b) Statistical process control/statistical quality control.
c) Plant optimization, data reconciliation, overall mass balance, etc.

d) Plant planning and scheduling.
e) Computer integrated manufacturing with information transfer to achieve functions like production and preventive maintenance scheduling and plant wide coordination etc.
5.2.6 The system as offered shall be fully and functionally integrated meeting the requirements specified above. In addition, the system shall also have capability and capacity to interact with smart and field-bus instrumentation simultaneously. The system shall also be capable of accepting signals from different type of field-buses in the same controller and data acquisition sub-system.

5.3 Controller and data acquisition sub-system (CDAS)

5.3.1 Controller and data acquisition sub-system shall primarily be used for plant control and data acquisition and shall interface with physical inputs and outputs from the plant and third party devices.

5.3.2 CDAS shall be microprocessor based and fully programmable sub-system which shall be capable of processing the acquired data from input / output devices utilizing a set of algorithms within its defined processing cycle. The microprocessors utilized in controller and data acquisition sub-system shall generally be of latest generation.

5.3.3 CDAS shall have a multi-processor architecture with each processor responsible to carryout predefined functions like Input / Output processing, control processing, internal communication, external interfaces etc.

5.3.4 The hardware and software capability of this sub-system shall primarily be exploited for processing regulatory close loop and open loop control functions only. Sequencing and interlocking capability shall be utilized whenever specified in job specifications.

5.3.5 CDAS shall be capable of accepting signals from various process sensors and devices with linear, non-linear and serial outputs preferably without requiring external or auxiliary signal conditioning devices and processing signals. Typically the inputs shall include 4-20mA DC (both conventional and HART), 1-5VDC, milli volt signal from thermocouples, resistance from resistance temperature detectors (RTD's), pulse input, field-bus (foundation field-bus, profibus PA etc.), serial inputs (MODBUS) and discrete contacts (powered or potential free), as a minimum. System shall also accept other inputs when specified in job specifications.

System shall be able to accept 2-wire, 3-wire and 4-wire signal inputs without any change in the I/O module.

5.3.6 The system shall have capability to generate analog 4-20mA DC (conventional or HART) current signal, 1-5VDC voltage signal, field-bus output signal, potential free contacts for discrete outputs and serial (MODBUS) outputs, as a minimum, apart from others specified in the job specifications.

5.3.7 The output from the system shall be capable of driving following loads;
a) Analog outputs shall be able to drive loads of output devices such as I/P converters, smart positioners, recorders / indicators etc. In general, it should have load driving capabilities up to 750 ohms.

b) Contact outputs suitable for driving alarm annunciations, status lamps, relays, converters, solenoid valves, contactors / breakers of motor control etc. In general, contacts rating shall as follows;

<table>
<thead>
<tr>
<th>Load Type</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intrinsically safe load</td>
<td>30V 0.5 Ampere</td>
</tr>
<tr>
<td>AC powered loads</td>
<td>230 V 5 Ampere</td>
</tr>
<tr>
<td>DC powered loads</td>
<td>110V 0.5 Ampere</td>
</tr>
<tr>
<td>DC powered loads</td>
<td>220V 0.2 Ampere</td>
</tr>
</tbody>
</table>

5.3.8 The system shall be capable of differentiating between out of range measurement (Bad process value) and a failed transmitter signal. In conventional 4-20mA output transmitter this shall be identified by setting bad quality data flags while for smart (HART) and field-bus transmitters data quality indicator from the device shall be utilized.

The detection of device failure alarm and driving output to a pre-defined value shall be configurable within this sub-system.

5.3.9 It shall be possible to override or force an input measurement or an output in the system while testing or on failure of an input.

5.3.10 Controller and data acquisition sub-system shall have an on-volatile memory for storing configurational data. In case vendor's standard product supports only volatile memory, battery back-up shall be provided to store the data for a period of 72 hours, as a minimum. A battery drain indication along with a potential free contact shall be provided to alert the operator.

5.3.11 The sub-system shall have sufficient memory to store the program instructions, CDAS data base, data required for real time trending and point trend and any other data required to be stored to meet specified functional requirements.

5.3.12 The sub-system shall incorporate a hardware or software based watch dog timer to monitor the healthiness of the CDAS processor-health.

5.3.13 Each controller and data acquisition unit shall have its own dual redundant power supply which can be replaced online. Separate dual redundant power supply unit shall be provided for powering field devices.
5.3.14 Controller and data acquisition sub-system shall be modular in construction with rack mounted modules in general. Input / Output modules shall be either rack mounted or DIN Rail mounted type.

5.3.15 Input / Output Modules

5.3.15.1 General

a) I/O modules shall communicate with processor modules serially either through back-plane or through I/O communication network. I/O network shall always be redundant. Data transferring through hardwired connections shall not be acceptable.

b) Analog to digit converters for analog 4-20MA / 1-5VDC modules shall meet the following requirements;

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/D Resolution</td>
<td>12 bits</td>
</tr>
<tr>
<td>Repeatability</td>
<td>± ½ LSB</td>
</tr>
<tr>
<td>Accuracy</td>
<td>± 0.1% of full scale</td>
</tr>
<tr>
<td>Common mode Rejection</td>
<td>60dB at 50Hz</td>
</tr>
<tr>
<td>Normal mode Rejection</td>
<td>55dB at 50Hz</td>
</tr>
</tbody>
</table>

c) Digital to analog converters for output module shall meet the following requirements;

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>D/A Resolution</td>
<td>10 bits (min.)</td>
</tr>
<tr>
<td>Repeatability</td>
<td>± 1 LSB</td>
</tr>
<tr>
<td>Accuracy</td>
<td>± 0.25% of full scale</td>
</tr>
</tbody>
</table>

d) Each output channel must maintain its own – failure mode value, which is automatically executed upon detection of a communication failure between process and output module.

e) Unless I/O module has universal design it shall have unique keyed facility to prevent faulty operation and termination.

In addition I/O modules shall also meet the specific requirements specified in clause 5.3.15.2 through 5.3.15.7.

5.3.15.2 Analogue Input / Output modules (conventional / smart)

The input module shall meet the following requirements;

a) It shall accept 4-20mA isolated input with maximum input resistance of 250 ohms or 1-5VDC isolated input with input resistance more than 500k ohms.

b) The input module shall support field powered transmitter i.e 2-wire, 3-wire or 4 wire system.
c) Input faults such as open circuit, short circuit and earth fault shall be detected by I/O module.

d) The output module shall provide 4-20mA output driving up to 600ohms of total loop resistance at 24V DC.

e) The system shall provide 24V DC for loop powered 2-wire transmitter and shall also loop power the 2-wire outputs.

f) Input / Output module shall not have more than 16 inputs or outputs.

5.3.15.3 Analogue Input / Output module with HART

a) The Analogue Input / output modules for HART signal shall meet all requirements specified in clause 5.3.15.2 above.

b) Input / Output shall fully support the HART communication signal i.e. the American Bell 202 standard frequency shift keeping signal superimposed at a low level on analogue measurement signal.

5.3.15.4 Foundation Fieldbus (H1) Interface Module

a) Foundation fieldbus H1 interface module shall be capable of supporting multiple segments and able to operate in full redundancy mode.

b) Foundation fieldbus H1 interface module shall always be provided in redundant configuration with Link Active Schedulers (LAS) configured in primary and back-up H1 interface modules respectively to ensure that failure of primary LAS shall not cause failure of H1 bus communication. Power for H1 segment shall be provided by power conditioner module which shall be separate from H1 interface module to ensure that failure or removal of H1 interface module does not affect the supply of power to the segment.

c) H1 interface module shall be supplied with link active scheduler (LAS) capability and running foundation fieldbus (FF) function blocks which include PID, PD, Bias, Gain, calculations etc. These function blocks shall be code identical to FB code provided in the field devices. The manufacturer shall guarantee the interoperability of H1 interface module with any function box residing in the field device.
d) Foundation fieldbus HI interface card shall utilize a fieldbus Foundation Registered mark.

e) The sub-system shall accept all the dynamic variables transmitted by the field-bus-device.

5.3.15.5 Temperature Input Module

a) The thermocouple input module shall accept grounded or ungrounded inputs from various thermocouple types i.e. T, E, J, K, R, S and B. The module shall be capable of linearising the thermocouple inputs and provide cold junction compensation.

b) The module shall have 12 bit resolution with digital accuracy of ±1°C

c) The RTD input module shall accept 100ohm platinum resistance temperature detector (Pt 100) in 3-wire or 4-wire configuration.

d) The module shall be capable of linearising the RTD input.

e) The module shall have 12 bit resolution with digital accuracy of ±0.28°C

5.3.15.6 Serial Interface Modules

a) Serial Interface modules shall be capable of communicating with RS232C, RS422 or RS485 signals.

b) Unless otherwise specified, all serial interface modules shall be configured in redundant configuration.

5.3.15.7 Discrete Digital Input / Output Module

a) Digital input module shall be capable of detecting close or open status of powered or potential free contacts. The interrogation voltage of the contacts shall be 24VDC or as per selected barrier for barrier powered contacts.

b) The input module shall also be suitable to accept inputs from proximity switches or from open collector output from proximity input barrier.

c) The digital output module shall provide output contact rated for 220V AC 10 Ampere 110V AC 5 Ampere or 110V DC 0.3 Ampere.

d) The type of contact output i.e. normally open or normally closed shall be user selectable.

e) Maximum number of inputs or outputs shall not exceed 32.
5.3.16 Fieldbus Segment Power supply and terminators

5.3.16.1 The power supply used for powering fieldbus segment shall have a impedance matching network, preferably part of power supply unit.

5.3.16.2 Short-circuit at spur level shall not lead to failure of any fieldbus segment except the short-circuited spur.

5.3.16.3 Unless otherwise specified, fieldbus power supply / conditioner shall meet the requirement of type selected instruments and shall be as per;

   a) Foundation fieldbus power supply Type 131 non – IS power supply intended for feeding IS barriers.

   b) Foundation fieldbus type 133 IS power supply compliant with IS parameters.

   c) For Non-Intrinsically safe segment, the power conditioner shall be capable of each drawing 20mA current supplying power to at least sixteen field devices including a segment terminator.

   d) For intrinsically safe segment, the power conditioner shall comply with FISCO or entity concept requirements as specified in purchaser's specifications.

   e) For a segment designed with Non-insendive concept, the power conditioner shall meet the requirements of FNICO.

5.3.16.4 Each foundation fieldbus power supply shall have redundant power conditioners (unless limited by concept design), current limited outputs to all foundation fieldbus segment and surge protection as applicable.

5.3.16.5 Individual power conditioners and input power supplies can be replaced without interrupting power or communication fieldbus segment.

5.3.16.6 Terminators

Terminators shall be provided by vendor at both ends of a foundation fieldbus segment. The terminator at DCS side shall be incorporated into the foundation fieldbus power supply / conditioner while field side terminator shall be installed in the junction box.

5.3.17 Control functions and algorithms

Controller and data acquisition sub-system shall have capability to perform conventional and advanced control algorithms for implementation of regulatory and advanced control strategies. This sub-system shall have real time computational capability and shall be able to perform following algorithms and computations in addition to those specified in job specifications;

   a) Control algorithms

       Proportional (P), Proportional – Integral (PI), Proportional – integral – derivative (PID), adaptive gain, feed forward, cascade, split-range etc.
b) Dynamic Functions
   Lead-lag, dead time, timers, counters etc.

c) Signal Selector
   High selector, low selector, high-low selector.

d) Calculation Blocks
   Linearisation, pressure-temperature compensation, polynomial, multiplication / division / addition / subtraction etc.

e) Signal Limiters
   Low limiter, high limiter, high-low limiter etc.

f) Logic Blocks
   Logic 'GATES' (OR, AND, NOR, NOT NAND etc), Flip-flops etc.

5.3.18 Controller shall be able to operate in either manual, auto, cascade or computer mode. Mode changeover in either direction shall be procedure-less and bump-less. Following functional capability shall necessarily be possible;

   a) In cascade loops, the primary controller shall be able to track the set point of the secondary controller when the secondary controller is not operating in cascade mode.

   b) In computer mode, controller shall be able to track computer generated set point and shall hold the last generated value in case of computer failure. In such case, controller shall fall back on auto-mode and continue to operate at the last received set point, in general. Other options like pre-defined set point operation and fail safe condition shall also be possible. On the resumption of computer set point again, the controller shall not return to the computer mode automatically.

   Computer failure indicator shall be provided at central and local level.

5.3.19 Controller shall accept the change in set point command from central level (as operator interface function) and take action accordingly. It shall have facility for slow and fast ramping of set point as well as output. In addition, it shall have anti-reset wind-up feature as standard.

   In addition to above, it shall also be possible to change set point, tuning constant, operating mode, controller configuration from the central level i.e. operator’s interface keyboard and engineer’s interface keyboard.

5.3.20 Loop Integrity
5.3.20.1 Loop integrity shall be maintained in controller functionality in such a way that the single component failure in the sub-system shall not effect more than one control loop (single loop integrity). This shall be achieved in offered sub-system architecture in one of the following ways;

a) By providing one to one controller back-up. In case failure is detected in the active controller all the loops of the failed controller shall be transferred to the back-up controller.

b) Where single loop controller is specified in the purchase specifications, no controller back-up shall be necessary provided no input other than that required for the specified loop is connected to the controller.

5.3.20.2 Loop integrity shall be maintained for the data acquisition functionality i.e openloop processing including processor such that a single component failure shall not effect more than 16 analog inputs or 32 discrete inputs.

5.3.20.3 Loop integrity shall also be applicable to I/O modules, power supply modules, communication modules and other associated devices as per the philosophy explained in clause 5.3.20.1 and 5.3.20.2 of this specification.

5.3.21 Sub-system Redundancy

5.3.21.1 In case of redundant configuration (where back-up components are provided), the design shall incorporate a fail-safe automatic control transfer switching mechanism which shall transfer the entire configuration, data base and loop control of the failed controller to the back-up controller. Design must also ensure that data integrity is maintained during switchover and no portion of data to be transferred is corrupted or lost before and during switch over to the redundant (back-up) controller. The indication of the failed controller / component shall be displayed at the level as well as on the central level.

5.3.21.2 The switchover from primary to back-up component / device shall be bumpless and transparent to the operator i.e. the outputs shall be held at the last value during switchover to avoid any process upset. The switchover time shall be of the order of one (1) second.

In case of redundant HI modules, the back-up module shall maintain connectivity with all publishers and shall subscribe to all publishers to minimise switchover time.

5.3.22 Sub-system configuration and on-line modifications

5.3.22.1 Controller and data acquisition sub-system shall be configured from the central level i.e. through engineers interface sub-system under password or hardwired key lock protection. Single loop controller when specified shall be configured from the local level.
5.3.22.2 Sub-system shall allow following configurational functions to be performed for each loop;
   a) Control function parameters
   b) Processor cycle time for each loop tagwise.
   d) Macro-cycle time for foundation fieldbus HI segment as per segment loading.
   d) Output status of each control loop in case of processor failure.

5.3.22.3 It shall be possible to carryout online modifications or perform back-up without interrupting the central
software of preventing the operator commands. Such modifications shall be possible without any plant
upset or process interruption.

5.3.22.4 Downloading of modifications to the respective controller and data acquisition sub-system shall be
possible in running condition.

5.3.22.5 Sub-system shall perform saving and back-up of data base as per changes made automatically.

5.3.23 System Diagnostics

5.3.23.1 Each module shall have a board diagnostic with on board LED for indicating status of the module at
local level.

5.3.23.2 All diagnostic subroutines shall carryout various diagnostic tests to check the healthiness. The test
shall include memory test (RAM and ROM), on-board processor test and back-up module
communication healthiness test etc. Failure of any of the tests shall be alarmed as module failure.

5.3.24 Sub-System Performance

The sub-system response time shall be the indicator for the performance of the sub-system. The
control system shall be able to perform control algorithm, calculation function etc. for each loop within
the specified response time unless specified otherwise in the purchaser's data sheets, the system
response time (scan time) and loop response time as defined in clause 2.22 and clause 2.26 (for
fieldbus based system) respectively of this specification shall be as follows;

- For flow and pressure close-loops - 500mS
- For temperature and level close-loops - 1000mS
- For analyser close-loops - 1000mS
- For all open loops - 1000mS
- For Interlock related inputs - 500mS
The processor cycle time shall be set to achieve the scan time and loop response time values specified above.

Scan time of multi-variable advanced control loops when implemented in controller and data acquisition sub-system shall be specified in purchaser's data sheets.

5.3.25 Controller & data acquisition subsystem loading

The system loading for controller and data acquisition subsystem shall not exceed 60%. The loading as indicated here is the worst case of high system activity referred to the use of memory, CPU time and communication capacity for this sub-system.

5.3.26 Sub-system Sizing

5.3.26.1 Sizing of controller and data acquisition sub-system shall be carried out considering the following parameters, as a minimum;

a) Unit-wise segregation of CADS as specified in the job specification.

b) Number and type of inputs / outputs specified in each unit in the job specifications e.g. analogue I/Os (conventional / smart (HART), Fieldbus I/Os, discrete I/Os etc.

c) Intrinsically safe and non-intrinsically safe I/Os.

d) Spares philosophy.

e) Distribution of spare I/O's in I/O modules

f) Scan time (Response time) and loop response time specified for each type of I/O.

g) Segment design criteria

h) Worst-case processor loading specified in the specifications.

i) Calculation blocks specified in the job specification. Following philosophy shall be followed for computing calculation blocks in addition to those indicated;

<table>
<thead>
<tr>
<th>PID Blocks</th>
<th>Calculation Blocks</th>
<th>Logic Blocks</th>
<th>Advanced blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>No of outputs</td>
<td>50% of PID Blocks or 130% of specified calculation Blocks whichever is higher.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>150% of specified blocks or 100% of specified Discrete outputs whichever is higher.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>150% of actual numbers specified.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For the purpose of block calculation, consider actual I/O's along with installed engineering spares. Also consider clause 5.3.26.2 (e) for fieldbus based system.

j) Serial interface modules in redundant and single configuration as specified.
k) Any parameter not specified above but required to be considered for size because of vendors standard sizing methodology.

Processor loading factor / calculation available in standard product guide for sizing shall be utilised else vendor shall reduce the sub-system block handling capability by a factor of loading.

5.3.26.2 In addition to relevant requirements specified in Clause No.5.3.26.1, following process control functionalities and requirement must be considered for fieldbus segment design;

a) The sensor device and the corresponding actuator in a control loop shall be on the same fieldbus segment.

b) Control loop that include a cascade type controller, the primary and secondary loop measurement as well as final control element shall be on the same fieldbus segment.

c) Split range measurement and final control element shall be on the same fieldbus segment.

d) Discrete fieldbus device used in an interlock alongwith a control loop, discrete device shall preferably be on the same fieldbus segment. Discrete device here means fieldbus converter.

e) The default configuration shall be for control (except high level calculations) to reside in fieldbus device. System shall be configured for control to fail over to CDAS

f) Type of hazardous area philosophy i.e entity concept, FISCO, FNICO or high power trunk.

g) Length of each segment with respect to the physical distance between control system (host) and field devices.

h) Loop response time or macro cycle time as specified.

i) Sufficient unscheduled time must be kept in each cycle to transmit a cycle information within defined loop response time. This shall be 50% of the specified loop response time.

5.4 Operator interface sub-system

5.4.1 General

5.4.1.1 The operator interface sub-system shall provide the centralized information to the plant operator/Engineer in the following fields:

a) Indication of all analog and digital process variables of control loops, open loops and all loop related parameters
b) Manipulation of control loops including changing set point, mode, output, configuration, tuning, and computational constants.

c) Alarm displays and annunciation.

d) Graphic displays and status indication.

e) Logging and trending including historical trend recording.

f) Trend recording on assignable trend recorders.

g) Self diagnostic messages.

5.4.1.2 The operator interface sub-system shall consist of a single or multiple operator consoles (VDU's driven by console electronics) and hardwired consoles. The number of consoles for a unit shall depend upon the size and operating philosophy of the plant. The number of console shall be specified in the job specifications.

5.4.1.3 The operator interface subsystem shall have either single tier construction or stacked construction. The type of construction shall be specified in the material requisition.

5.4.1.4 The operator station shall comply with ISO 9241-5 'Workstation layout and postural requirements' and ISO 9241-7 'Display requirements with reflections'. The layout of the operator interface sub-system shall be as indicated in the material requisition. The consoles required to meet the shape and symmetry indicated shall be supplied by the vendor.

5.4.1.5 Unless otherwise specified in job specifications, each VDU shall be a 459.7mm active matrix TFT type LCD display unit and shall have native resolution of 1280 x 1060 pixels, as a minimum, with a 160° wide viewing angle.

5.4.2 Operator Consoles

5.4.2.1 Each operator console shall consist of the following;

a) Single tier construction shall have three (3) VDU screens with its own dedicated keyboards (a total of three keyboards) each driven by an independent electronics.

b) Stacked construction shall have the two stacks of VDU's with four VDU's (2VDU's / stack) and two sets of keyboards (one keyboard / stack) each stack driven by an independent electronics.

c) Each operator video screen or 2 VDUs of stacked construction shall be driven by a dedicated driver electronics which also keeps the desired data base for various functions defined and termed as
workstation. All the three operator workstations shall be operationally interchangeable in such a way that all the three workstations have similar data base and functionalities.

d) The operator console shall also have a logging printer, a alarm and event printer and a hard copy unit, unless otherwise specified in job specifications.

5.4.2.2 Hardware Configuration

The operator console shall meet any one of the following configuration options;

5.4.2.2.1 Option I

Each operator video screen shall be driven by a dedicated driver electronics which also keeps the desired data base for various functions defined and termed as workstation in this case each as has data stored in it should be minimum RAID-5 configuration to ensure maximum availability of history/data. All the three operator workstations shall be operationally interchangeable in such a way that all the three workstations have similar data base and functionalities.

5.4.2.2.2 Option II

One or more number of operator console (consisting of three video screens and dedicated keyboards) are driven by a common redundant server machine storing a common database for all the three video screens (three video screens may work like clients to this server). Server shall be a multifunction higher end server grade machine which may support functionalities such as;

a) Data connectivity between CDAS and other sub-systems (i.e. operator sub-system, engineering sub-system, IAMS etc.)

b) Database storage and engineering functionality as per Clause 5.4.2.3 of this specification.

c) Historisation of data related to associated operator consoles.

This server can also be used for functions like;

a) Plant history (UHN)

b) Connectivity to information network or OPC node.

c) Running specific applications like generating advance controls, MIS reports, IAMS, AIMS etc.

5.4.2.2.3 Option III

a) Two parallel servers (each containing same data base, each driving), two of the operator console VDU’s are driven by a server which stores complete data base for the units being assigned. In this case, operator console shall have four operator console VDU’s (instead of three specified as operator console). Similar philosophy shall apply in case of stacked VDUs operator console.

b) In case, multiple servers are used to support different functions like data connectivity, data base storage and historian function, similar philosophy as 5.4.2.2.3(a) may be followed.
5.4.2.3 The system shall have global data available at each operator console electronics and all the functions explained in Clause 5.4 shall be available / executed at operator console. However, in case functionalities are distributed in various intelligent hardwares / softwares or in case of distributed database / console functions is supported by the standard system architecture, each data base electronics / functionality shall be RAID 5 configuration dual redundant. Further any change made in the data base of one operator console shall automatically update the data base of other operator consoles if configured identically. Following shall apply;

a) history function, for the units monitored and controlled from the operator console, shall be RAID 5 configuration dual redundant with each node have dual disc drives dedicated for history storage.

b) Data base storage function for the units being monitored and controlled by the unit shall be RAID 5 dual redundant and shall have dual disc drive configuration.

c) All stations used for data storage and such functionalities shall have RAID5 configuration.

5.4.2.4 The operator, as a minimum, shall have access to the following through the operator key board at all times:

a) Selection of all the displays including the direct selection of loop in alarm, page turning facility, overview, group view and loop view selection etc.

b) Selection of loop for operation.

c) To acknowledge alarms as and when they are annunciuated on the operator console.

d) Facility to enter any changed parameter like setpoint, manipulated variable, digital commands and to cancel any wrong entry while making such change.

f) Facility for easy positioning of cursor for the selection of any parameter.

g) Selection of hardcopy printout, logging printout, alarm history printout and assignable trend recorder points.

h) Auto/manual/cascade/computer mode changeover of each controller.

5.4.2.5 In addition the Engineering keyboard shall have the following capabilities for restricted user/engineer through a key-lock or with password protection;

a) Data base configuration including overview, group, loop, multi-loop and multi-variable control configuration.

b) Group or multi-group alarm inhibit from a plant under maintenance.
c) Reconfiguration of alarm settings and their values, addition and deletion of components in a loop.

d) Tuning of control loops including change of P, I, D and dead-time contacts

e) On-line compilation of graphic displays using standard user defined symbols.

f) Changing of parameters to be logged.

g) Setting of real time clock.

h) Assigning of parameters for historical trending.

i) To call detailed self-diagnostic for maintenance.

Any change made for any parameter for an input from any display shall be automatically updated on all displays configured for that input.

5.4.2.6 Operational Protection

A key-lock switch or software password shall be provided for operational protection. Following minimum level of access and authorisation shall be available;

- Operator Level: Authorises all commands for plant operation.
- Engineers level: Authorises all commands for plant operation and system engineering.
- Management Level: Authorises all operational data and reports to be viewed.

Other levels of key-lock / password protections if available as standard with the system shall also be offered.

5.4.2.7 It shall not be possible to override any process variable or digital status from operator keyboard.

5.4.2.8 Each keyboard either integral or as a separate attachment shall have a set of dual function user configurable keys. These keys shall be configured to access important pages in single keystroke. These keys shall have LEDs which flash on pre-configured alarm conditions. A minimum of 32 number of such keys shall be offered with each keyboard. Systems, which do not support dual function keys with their standard keyboard shall offer either;

- i) a dedicated VDU and keyboard with each operator console configured with an intelligent graphic which would replicate the functionality of dual function keys.
- ii) a dedicated keyboard with dual function keys alongwith each standard keyboard.

5.4.3 Process displays
5.4.3.1 Process information and operational aids shall be presented to the operator in the form of display. These displays shall cover all points related to tag numbers built within the system. The process displays shall include different type of displays and the functionalities associated with each of these displays. Various types of process displays, as envisaged, are detailed out in the clauses to follow. The details provided herein are typical and explain only the functional requirements. The systems as offered must provide displays which meet these functional requirements.

5.4.3.2 Overview display

5.4.3.2.1 Overview display shall present the overall status of a unit or large segment of the process plant. The analysed data and alarm conditions are displayed with colour changes.

5.4.3.2.2 Overview display shall incorporate a minimum of 128 analog or discrete inputs which can be monitored simultaneously on the VDU screen (Referred as page). Each page shall be organized into a suitable number of groups. Each group shall be identified separately. Each group shall further incorporate suitable number of inputs (Referred as tags). Suitable identification and description shall be shown for each group on the overview display to relate it to a group or loop display.

5.4.3.2.3 All analog points in the overview shall be represented as variable lengths indicating deviation above or below the normal operating value or set point.

5.4.3.2.4 Alarms shall be displayed in change of colour against each variable if the variable crosses a set value. Control loops operating in manual mode shall be indicated.

5.4.3.2.5 An input in alarm condition shall be identified by flashing.

5.4.3.2.6 In case, any hard wired instrumentation backup is provided, overview pages shall be assigned indicating the tag number and type of hardwired instrument.

5.4.3.2.7 The operator shall be able to call directly any group display or loop display or any predetermined displays covered in the overview display.

5.4.3.2.8 It shall not be possible to acknowledge alarms directly from the overview display.

5.4.3.3 Group Display

5.4.3.3.1 Group display shall be limited to the group of inputs as displayed in the overview display. Each group shall preferably include eight (8) number of inputs.

5.4.3.3.2 Each input in the group shall be identified by the tag number, unit of measurement and process description which shall be displayed on the VDU screen.
5.4.3.3 Display, as a minimum, shall show following degree of details:

   a) Process variable in analog form shall show, as a percentage of the transmitter span on a linear scale bar graph of 0-100% or engineering units and in digital form as alphanumeric display in engineering units.

   b) Set point value in analog form as a percentage of the transmitter span on linear scale bar graph of 0-100% engineering units and in digital form as alpha-numeric display in engineering units.

   c) Output value in analog form as a percentage of linear scale bar graph of 0-100% and digital form as percentage.

   d) Controller mode i.e. auto, manual, cascade, computer.

   e) Process alarm on process variable, deviation or velocity.

   f) Selected loop within the group shall be identified by cursor marking or similar identification.

   g) Control valve failure position.

   h) The contact input / output shall be represented by simulated graphic lamps and configurable alphanumeric status description.

5.4.3.4 It shall be possible to control the process from group views. Following control actions shall be possible;

   a) Increase / decrease of set point value either slow or fast.

   b) Change of controller mode i.e. Auto/manual transfer.

   c) Changing output to the final control element.

   d) For digital points, start/stop or open/close command.

5.4.3.5 It shall be possible to repeat any tag number in more than one group/console. However it shall be possible to control or change configuration from only pre-assigned group/console.

5.4.3.4 Loop Display

5.4.3.4.1 Loop display shall provide a separate detailed display for each of the process inputs. The graphic representation of analog and digital points shall be similar to group display. However in addition following information shall also be presented in alphanumeric form as a minimum

   a) Controller tuning constants.

   b) Process variable zero and span values.
c) Alarm set point on various parameters.

d) Limits on set point, output, velocity etc.

e) Controller action (direction/reverse).

f) Failure position of final control element.

g) Computational constants like ratio or bias.

h) Integrated value.

i) Output to the final control element.

j) Engineering units.

5.4.3.4.2 It shall be possible to change the following through the keyboard of operator console:

a) Tuning constants.

b) Scale, zero and span.

c) Limits on set point, output, velocity etc.

d) Configuration of any loop.

e) Alarm set points.

f) Control mode.

g) Output to the final control element.

h) For digital points, it shall be possible to issue start/stop or open/close command.

5.4.3.4.3 Loop control parameters changes as specified in para 5.4.3.4.2 (a) to (e) shall be restricted by a key lock control or password.

5.4.3.4.4 The loop display shall also contain a trend displaying process variable, set point and output with a sample interval time of maximum 1 second and full scale time base of minimum 60 seconds for tuning the process control loops.

5.4.3.5 Graphic display

5.4.3.5.1 It shall be possible to display dynamic graphic of different sections of plant on the operator console VDU screens. Graphic displays shall be field configurable only through engineering key-board with standard / user defined graphic symbols. Dynamic graphic displays if different sections of the plant shall be displayed on different pages.

5.4.3.5.2 The system shall have graphic symbol library as per ISA-5.1 and 5.3. In addition standard industrial symbols like distillation columns, heat exchangers, pumps, compressors, tanks etc. shall also be provided as a standard.
5.4.3.5.3 Graphic displays shall be interactive type through which it shall be possible to control the process. It shall also be possible to send motor start/stop and shutdown valve open/close commands, as specified in job specifications, from this display.

5.4.3.5.4 It shall be possible to view the process variable and alarm points and view and change set point value, manipulated variable, controller mode etc. from the graphic display. Also rotating machinery (i.e. compressor / pump) status and valve status shall be displayed on the graphic display with different colours.

5.4.3.5.5 Various colours used in the generation of graphics like colour of the process lines, utility lines, Instrument signal lines and event modifier conditions shall be finalised during detailed engineering. The colours used to identify event modified conditions shall generally be as follows unless otherwise indicated during detailed engineering.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>All points alarm</td>
</tr>
<tr>
<td>Blue</td>
<td>Valve open, pump running.</td>
</tr>
<tr>
<td>Green</td>
<td>Valve closed, pump stopped.</td>
</tr>
<tr>
<td>Flashing green</td>
<td>Shut down valve transition state.</td>
</tr>
</tbody>
</table>

5.4.3.5.6 It shall be possible to go from any graphic page to related graphic pages or any group view or alarm summary in single key stroke using soft key function.

5.4.3.6 Trend Display

5.4.3.6.1 The system shall be capable of displaying the following trends:

a) Real time trends for the parameters specified in job specifications displaying current data for a period of minimum one (1) hour as defined in clause 2.33 of this specification. However it shall be possible to assign any parameter for real time trend.

b) Historical trend for number of parameters as specified in the job specification for a period of 30 days with sampling rate of 10 minutes. However, it shall be possible to assign any parameter for historical trending.

5.4.3.6.2 Historical data shall be stored on the nonvolatile memory device like hard disc in such a way that such historical data can be utilized for archival storage and subsequent recall.

5.4.3.6.3 Real time and historical trend shall be possible on any parameter or variable like measured variable, set point, output, calculated variable etc.
5.4.3.6.4 It shall be possible to sample and store data of instantaneous and average value at the intervals mentioned below. However it shall be possible to display by scrolling or expanding the time base for all the trends.

a) At intervals 1 second or higher for the real time trend.

b) At 1 minute, 10 minute & 1 hour interval for historical trend.

Historical data trends shall be displayed for a period of minimum up to 72 hours for a data sampling rate of 1 minute.

5.4.3.6.5 The requirement of fast trend (trends with sample time faster than Real time trend) if any, shall be specified in the job specification. This shall be in addition to tuning trend requirement specified in this specification.

5.4.3.6.6 Selection of the tag number and sampling time for real time and historical trending shall be possible from operator keyboard.

5.4.3.6.7 The system shall also have a multi trend capability in such a way that it shall be able to display set point, measured variable and output on the same display, the trend of either the same process variable or any other process variable.

5.4.3.6.8 Trend display shall be single line type or bar graph type with additional information like loop tag number, engineering units, span, present value of the trended point, alarm status etc displayed.

5.4.3.7 Closed Circuit Television Window display

It shall be possible to display close circuit television (CCTV) video monitor image on the operator console as a CCTV window. A function key on the operator keyboard shall be assigned to select the desired CCTV monitor window. The CCTV window on the operator console video shall always be on-top.

5.4.3.8 Alarm Monitoring and display

5.4.3.8.1 Alarm Management

a) It shall be possible to display process as well as system alarms on the operator console for operator’s attention and action. Alarms shall appear immediately on the operator console as and when they occur on priority basis.

b) It shall be possible to set process alarm limits from the engineering keyboard i.e. alarm limits on absolute value of measured variable; rate of change of measured variable; high and low deviation set points; high, extra-high, low and extra-low points on process variable and output etc.
addition, it shall be possible to derive alarm conditions on the basis of few calculations performed by the system.

c) Alarm messages shall be displayed by flashing the page and group number of the input under alarm irrespective of type of display. It shall be possible to access the group or tag in alarm condition with a maximum of two key-strokes of operator’s console keyboard. The plant overview display, in addition to display alarm message, shall also be able to provide warning by changing colour of excessive deviation of process variable from their set value.

d) All alarms shall be displayed as and when they occur or generated with change in the colour of display in the following sequence, activating an audio signal:

Continuous flashing : Un-acknowledged alarm
Steady display : Acknowledged alarm

e) The system shall not put off the audio alarm and visual flashing even after the condition returns to normal unless it is acknowledged by the operator.

f) In order to provide immediate attention to critical alarms, alarms shall be classified in the priority of their criticality.

g) In addition to alarms appearing on the different displays as mentioned in para 5.4.3.1 to 5.4.3.5 of this specification, the system shall also be able to display alarm summary and alarm history as per para 5.4.3.8.2 and 5.4.3.8.3 of this specification.

5.4.3.8.2 Alarm summary display

a) It shall be possible to display summary of all alarms in the sequence of their occurrence and shall disappear from display only when they are acknowledged and cleared. The alarm display shall list the following for each alarm as a minimum:-

i) The date and time of occurrence.
ii) Point identification (i.e. Tag number)
iii) Point description.
iv) Type of alarm (absolute value or deviation.)
v) Serial number of alarm in the sequence of its occurrence.

b) The system shall be able to display on alarm summary a minimum of 100 alarms.

c) Alarms shall preferably be listed in the form of alarm list like current, List I, List II etc. The minimum number of alarms per list shall be 25. Alternately system may provide a common list of alarms in the sequence of their occurrence (with respect to time).

5.4.3.8.3 Alarm history
a) The history of alarm conditions shall be maintained in the database for alarm history display and printed on shift-wise basis for the parameters specified in the job specifications. The alarm display and print out shall list the following for each alarm as a minimum:-
   i) The data and time of occurrence.
   ii) Point identification (i.e. Tag number)
   iii) Point description.
   iv) Type of alarm (absolute value or deviation.)
   v) Time of acknowledgement.
   vi) Time of return to normal.
   vii) Serial number of alarm in the sequence of occurrence.

b) The system shall be able to display and print out the alarm history of minimum of 300 alarms.

c) Alarms shall be listed in the form of alarm lists like List I, List II, List III etc. The minimum number of alarm points per list shall be 25. Alternately system may provide a common list of alarm in the sequence of their occurrence.

5.4.3.8.4 System alarm

a) System shall have capability of on-line self diagnostics as mentioned in para 5.4.5 of this specification.

b) Any abnormal conditions in and sub-system or any other functional device shall be displayed as system alarm message on the operator console irrespective of the display selected.

5.4.3.9 Configuration display

5.4.3.9.1 Configuration display shall provide a separate detailed display for each loop indicating the configuration of that loop. When control requires more than one loop, all interrelated loops shall also be displayed. Following information is required to be available on configuration display.

a) Loop configuration giving designation of each block.

b) Control block interconnection showing soft-wiring or hardwiring.

c) Value of each block parameter like P.I.D., ratio, bias, dead-time, lead- time etc.

5.4.3.9.2 It shall be possible to configure & reconfigure the loops from this view using user friendly software.

5.4.4 Logging and Report Generation function

5.4.4.1 It shall be possible to log all real time data, historical data, computed parameters, operator actions, alarms and events etc from operator consoles irrespective of data source connected to communication sub-system. In general, the data type shall include;

a) All measured and manipulated variables (inputs as well as output data)
b) System calculated variables

c) Historical data values

d) Alarm and event data

e) Operator data entry and operator actions

f) Equipment status data

g) Data through serial links

h) Data through OPC server

i) Batch related data

j) System clock time

k) System diagnostic data

5.4.4.2 The system shall have a report builder and report scheduler which shall have following capabilities;

a) The system shall be able to generate reports on hourly basis, shiftly basis (8 hourly), daily basis and in some cases weekly or monthly basis, as specified in job specifications.

b) The system shall be able to generate reports as per operator command either on-demand or on predefined time.

c) In general, the type of reports shall be;
   - On demand report initiated by operator action
   - Predefined time initiated report e.g. hourly, shiftly, daily etc.
   - Event driven report
   - Shutdown driven report
   - Equipment runtime status report

d) The generation of on demand report shall not affect any scheduled report.

e) These reports shall be stored in separate files independent from historical and trend data files.

5.4.4.3 All parameters required for logging shall be stored in the system memory as per data base update rate. The system shall be able to perform following functions on all such stored data prior to logging as per the requirement of the report;
a) Basic arithmetic calculations such as averaging, summing, multiplication, division etc.

b) Advanced calculations like efficiency calculations, conditional calculations etc.

c) Extended log reports such as weekly and monthly reports.

d) Batch Reports

5.4.4 The formats used to generate log reports shall be user definable, in general. Typical log formats for hourly, shiftly and daily reports have been attached alongwith (Refer Annexure 1) for reference. System shall have a user friendly structured programming language suitable to generate and access various reports. System may utilize high level language for generating reports with advanced calculations. High level language compiler software shall be supplied as part of standard system function.

5.4.5 Number of log reports generated for a project shall be governed by the number and type of log formats defined for a project like hourly report format, daily report format, shutdown report format etc. Number of pages in each log report shall be sufficient to accommodate all the parameters defined in the job specifications.

5.4.6 In addition to the real time and historical data, the report builder programme shall incorporate report title, sub-headings, notes and messages.

5.4.7 Hourly report shall be printed only as and when initiated on demand by the operator and shall not be printed automatically after the end of the hour. All other reports shall be printed automatically at the end of the pre-defined time as well as on demand by the operator. The maximum storage time for a log information shall be 15 minutes after the pre-defined print out time for a format, within which time log report must be printed. In case report could not be printed within the scheduled defined time, data shall remain stored till the report is finally printed.

5.4.8 Logging hardware

Data required to be logged shall be finalised during log report finalisation stage. However, typically following shall apply;

a) All tag numbers, analogs as well as digitals, shall be available for hourly log.

b) All flow tag numbers and other selective tag numbers shall be available for daily log report.

c) Only selective tag numbers shall be available for weekly and monthly report.
d) Average (over the defined period) for flow and instantaneous shall be used for log printing with maximum and minimum value as defined in log formats.

5.4.4.9 Logging Hardware and Software

5.4.4.9.1 The system shall be supplied with all hardware and software necessary to meet functional requirements specified in Clause 5.4.4.7 of this specification. Log reports shall be generated, compiled and printed using system standard hardware and software. No separate computer / server shall be used.

Separate server, if necessary, may be utilised, to generate extended logs or reports requiring advanced calculation.

5.4.4.9.2 It shall be possible to archive log reports on an external computer. Facility shall also be available to retrieve these reports as a magnetic tape or a disc for future reference.

5.4.4.9.3 In the event of printer failure, the system shall maintain the data in the point buffer memory of the report originating device buffer with a printer failure alarm.

It shall also be possible to print the report at an alternate printer without any data loss, whenever necessary.

5.4.4.9.4 System Printers

a) In addition to configuration and maintenance (C&M) printing, printers shall be used for printing reports like log reports and alarm and event reports.

C&M printers shall be dedicated for each machine whenever such a function is required.

b) All printers shall be low noise industrial type and shall be suitable for continuous duty.

c) Logging printer

Logging printer shall be A3 size colour laser printer and shall be able to meet the following requirements;

i) Logging printer shall be able to print the following reports;
   - Printing of hourly, shift-wise, daily and weekly log.
   - Shut down report printing.
   - Any other report defined in the job specification.
ii) In addition to above, logging printer shall also be used for printing hard copy of any video screen, whenever necessary.

d) Alarm and event printer

Alarm and event printer shall be low speed dot matrix printers capable of meeting the following requirements;

i) Alarm and Event printer shall be able to print out following reports;

- Log the process and system alarm messages with a time stamp as and when they occur
- Print the alarm history for every shift of operation or on demand from operator console.

- Log events such as operator actions as defined in para 2.30 of this specification, as and when they are initiated.
- System alarms as per self-diagnostic reported alarms.

ii) Alarms and Events shall be clearly distinguishable on the report, preferably by colour.

iii) Print out shall show as a minimum the tag number, description, date and time of occurrence, time of acknowledgement and time of return to normal.

iv) The time stamp shall include month, day, hour and minute.

e) Multifunction printer

Multifunction printer be a colour laser printer which shall be able to print out log reports as well as alarm and event reports. Multifunction shall be specified either common for a unit or a group of units. The functionality of multifunction printer shall be same as (a) through (d) specified in clause 5.4.4.9.4 of this specification.

The command for printing of any report shall be generated from any operator and / or engineering console. The reports shall be generated in the priority of which shall be as per request time for printing report.

f) Hard-copier

i) Hard-copier shall preferably be a coloured heavy duty laser printer. The command for copying shall be initiated from any operator console.
ii) The screen display may be changed on the console after the copy command is initiated for any screen. This video copier shall have buffer memory storage for at least two screen pages.

5.4.5 Self diagnostics

5.4.5.1 The self diagnostic message for a subsystem failure shall appear on the operator console irrespective of display selected. The choice of the detailed self diagnostic displays shall be made by a key-lock switch.

5.4.5.2 The system shall have an extensive set of self-diagnostic routines which shall locate and identify the system failure at least up to module level including redundant components.

5.4.5.3 At the local level, failure of a module in a sub-system shall be identified by an individual LED display.

5.4.5.4 Failure of a subsystem shall be annunciated with the change in colour. To aid system maintenance and for effective fault location, following displays shall be provided as a minimum.

5.4.5.4.1 Communication system status display.

The display shall show an overview of different sub-systems connected over the communication sub-system showing status of each sub-system. When a failure is detected by the system self diagnostic routine, the display shall indicate the location and nature of malfunction. Display shall as a minimum have
- Type of sub-system.
- Failure of communication bus/link with the sub-system.

5.4.5.4.2 Sub-system diagnostic display

One display page shall be available for each sub-system on the communication sub-system which can be called on demand.

The display as a minimum shall contain:
- Sub-system number and type
- Error code and description
- Details of failed module

5.4.6 Data Storage, Archival and Retrieval

5.4.6.1 **Historical data shall be stored on a non-volatile memory device like hard disc which can be subsequently recalled by operator on any screen. System must support multiple historical data discs in order to avoid data loss in case of disc crash.**
5.4.6.2 It shall also be possible to store and retrieve this data on removable mass storage media like floppy disc, cartridge or tape etc.

5.4.7 Assignable Trend Recorder

5.4.7.1 It shall be possible to provide real-time trend on the assignable recorders for any process or calculated variable. The variable shall be assigned through the keyboard of operator console on any point and any recorder connected to that console.

5.4.7.2 Assignable trend recorders shall be located on the hard wired console. Each recorder shall have four pens.

5.4.8 Hard copy unit

5.4.8.1 Hard copy unit shall be used to make permanent copy of any VDU page when demanded through the operator console/Engineer console.

5.4.8.2 VDU page shall not be locked for more than 5 seconds while taking the video-copy.

5.4.8.3 Copies of display shall be in full colour.

5.4.9 System Servers sizing criteria

5.4.9.1 The servers provided as part of standard system architecture shall have fault tolerant architecture with a minimum availability of 99.999%. The design requirements of each server shall be dependent on its functional requirements such as;

a) Guaranteed throughput performance.

b) Continuous and consistent data connectivity even during fault.

c) Continuous and consistent processing of data even during fault.

d) Fault tolerant operating system.

The fault tolerant configuration of server shall include synchronised redundant processors such that failure, if any, is transparent to the user and server applications.

Transparent to the user implies that the data display on the graphic of any VDU shall not be lost for more than three (3) seconds in case of failure of the main server.

5.4.9.2 In case if redundant server configuration, the maximum switchover time shall not exceed ten (20) seconds.

System servers which have switchover time exceed 3 seconds, shall ensure that real time data is available on at least two of the three operator console VDU’s even during switch over.
5.4.9.3 All machines that are used for data is storage shall be high end server grade machine with minimum RAID – 5 configuration. General purpose servers below RAID 5 configuration shall not be acceptable.

5.4.9.4 Server Sizing

5.4.9.4.1 Unless otherwise specified, following criteria shall be considered while sizing the server/ servers used for driving operator console (for configurations where data is not stored in the operator station);

a) Number of operator workstation (clients)

   Consider 1.2 times the specified number of operator workstations rounded to next higher whole number for each type.

b) Number of Engineering workstations (clients)

   Consider 1.2 times the specified number of engineering stations rounded to next higher whole number.

c) Number of Controller and data acquisition nodes

   Consider 1.4 times the specified number of CDAS nodes.

d) Maximum number of nodes/sub-systems on the network should be less than 60% of the system capacity specified in the standard printed catalogues of manufacturers.

e) Maximum history storage tag numbers per second

   Consider 1.4 times the specified number of tag points in the material requisition with storage rate of 1 second.

f) Maximum number of trends

   Consider 1.4 times the specified number of trend points. Where no separate trend points are indicated consider all analog inputs and outputs as required trend points.

g) Maximum number of Reports

   Maximum number of log reports (formats) shall be 50 with 1000 points in each log report.

h) Maximum number of Tag data

   Consider 1.4 times the total number of tags and associated parameters i.e. process variable, set point, manipulated variable, auto-manual-computer status, alarm values, diagnostic data from field devices, serial data (process and diagnostics) from third party devices SOE data etc.

i) Maximum number of process alarms, operator events and operator messages

   Consider 1.4 times the maximum specified parameters. Where no operator-events or operator messages are indicated in material requisition, consider a total of 1000 points for sizing.
j) Number of Peripheral devices
   Consider 1.4 times the maximum number of peripheral devices specified in the configuration diagram.

k) Maximum number of fieldbus segments
   Consider 1.4 times the maximum number of fieldbus segments specified or computed by the vendor, as applicable.

l) Maximum number of data for UHN and OPC node (If applicable)
   Consider 1.4 times the maximum number of tag data specified in the job specification. Where no separate data is given in the job specification consider through put requirements specified for UHN and OPC node sizing in this specification. The polling rate shall be considered as 1000 tags per second.

m) Maximum amount of Asset Management data
   Consider 1.4 times the maximum data available from field devices for asset management.

5.4.9.4.2 While sizing the server / system consider the following operational features;

   a) Number of Operator Console VDU (WS) with over view display: 33% of 'A'
   b) Number of operator console VDU’s (WS) with trend displays: 33% of 'A'
   c) Number of operator console VDU’s (WS) with graphic displays: 33% of 'A'

   Consider 'A' as number of workstations specified in clause 5.4.9.4.1(a) of this specification.

5.4.10 System Operational Response Time

   The system shall meet the following response times beyond which the delay may have detrimental effect on the operator's performance;

   System activation or Logging-on of a terminal: 1 sec.
   Display call-up time
     - Simple pages like menu display: 0.5 sec.
     - Graphic page: 1 sec.
   Command execution response: 4 sec
   Data entry error reporting: 1 sec.
   Response to mouse / keyboard commands: 0.5 sec.

5.5 Engineer interface sub-system
5.5.1 Engineer interface sub-system shall be primarily an engineer's interface which shall normally be used for configuring, tuning and maintenance of the Distributed Control System. This sub-system shall also be used as operator console whenever necessary (e.g. during start-up etc).

5.5.2 It shall consist of an Engineering console which shall be able to perform all engineering functions related to each operator console and other sub-systems e.g. controller and data acquisition sub-system, interface devices etc (except PLC for which dedicated engineering console shall be provided). It shall also be possible to configure field-bus function blocks on any segment from engineering console.

5.5.3 Each Engineering console shall consist of single or multiple colour 459.7mm active matrix TFT LCD video screens with full integrated audio capability and shall have an integral USB hub. The video screen shall have a native resolution of 1280 x 1024 pixels with wide viewing angle. Each engineering video screen shall be provided with one operator key-board and one engineering keyboard. This, as a minimum shall also have one configuration and maintenance printer.

5.5.4 Engineering console shall also have, the capability of an operator console. However, the operation of the plant shall be restricted from this console. All the operator console displays as specified under clause 5.4.3 of this specification shall also be available on Engineering console.

5.5.5 Engineering console like any other sub-system shall be capable of communicating with all other sub-systems over the communication sub-system.

5.5.6 Engineering console shall have individual dedicated electronics with RAID 5 disk configuration.

5.5.7 It shall be possible to perform all system configuration functions and configuration modification functions from the Engineering console typically;

a) Data base configuration including overview, group view, loop view, trend view, sequential programming, multi-loop multi-variable control configuration for connection, smart and field-bus based inputs.

b) Group or multi group alarm inhibit from the plant under maintenance.

c) Configuration or re-configuration of alarm settings, their values, addition or deletion of any control block or component in a loop.

d) Compilation of graphic displays.

e) Setting of real time clock.

f) Compilation of logs/reports/historical trend points.
5.5.8 Configuration Requirements

5.5.8.1 It shall be possible to configure conventional, smart (HART) and fieldbus I/O's and control strategies the same way. The device configuration application for HART and fieldbus devices shall utilize EDDL or FDT / DTM as specified in data sheet. It shall include the following:
   a) Capability to display all device parameters directly from the device itself.
   b) Modify and download device configuration directly to device.
   c) Separate display of process values and device alarms.
   d) Capability to modify multi-device and download all at the same time.

5.5.8.2 Fieldbus HI interface configuration
   a) The configuration software shall have capability to configure all HI fieldbus interfaces such as;
      - LAS assignment and management
      - LAS scheduling
      - Macro cycle time calculations / optimisation
   b) Interface configuration software shall support multiple LAS as a segment. Graphical tool shall be provided which shall provide sequence of execution, execution time of each fieldbus device and overall macro-cycle time.

5.5.8.3 Fieldbus Function blocks
   a) The configuration software shall be able to configure all fieldbus functional blocks available in fieldbus devices.
   b) Function block configuration shall be downloaded from engineering console to field devices on line.
   c) Downloads that will result in change in segment macro-cycle shall proceed with a positive confirmation before the download is allowed.

5.5.8.4 Segment Scheduling
   a) The engineering software shall have capability to carryout segment scheduling against the scheduling constraints such as number of parameters which LAS can transmit during the single cycle.
   b) Response time for an HI segment shall be from 32μ seconds to 2.2milliseconds.

5.5.8.5 Automation configuration tool

5.5.8.5.1 The configuration software shall be capable of auto-detection of following I/O devices;
   a) Identification of I/O ports and all types of I/O modules with software configuration defined. If mismatch is detected, an alarm message shall be generated.
b) Function block configuration tool shall be capable of identifying the installed field devices. An alarm message shall be generated in case of mismatch.

c) Automatic address and tag name assignment for fieldbus devices. These capabilities shall also include handling of any foundation fieldbus registered device using the device DD and CFF files.

5.5.8.5.2 The system shall be pre-configured to identify the attributes of all I/O interface ports and general characteristics of any connected field device, which comply with FDDL (of latest version) or FDT / DTM as specified.

5.5.9 Tuning of a control loop shall be possible from Engineering as well as from operator console, the location for tuning shall be selected by the operator.

5.5.10 On-line Configuration
The system shall have the capability to copy, store, modify and restore the configuration data on-line without shutting the system partly or completely. The system shall be capable of downloading controller configuration from engineering console without taking controller off-line.

5.5.11 Off-line Configuration
5.5.11.1 It shall be possible to generate system configuration i.e. controller and data acquisition sub-system and display configuration including graphics from an independent PC with windows software loaded. System engineering features like continuous control, advanced controls, displays, alarm, historical functions, logging functions etc. shall be configurable from above station. The configuration shall be possible without the availability of actual engineering station. Configuration generated off-line shall be loaded on to engineering station without any limitation.

5.5.11.2 Fieldbus engineering software tool shall be able to perform offline fieldbus engineering by accessing CFF and DD files of field devices without connecting the field devices.

5.5.12 During the normal operation, the Engineering console, in no case, shall interfere with the process operation or system software. However any change in the configuration shall be down loaded into the system with proper knowledge of the operator.

5.5.13 All detailed diagnostics of the system shall appear on the Engineering console with a print out on the Configuration and Maintenance (C & M) printer. A common diagnostic message on the operator console shall indicate the need of the maintenance.

5.5.14 To aid the system maintenance and effective fault identification, following displays shall appear on the engineering console;

a) Communication system status display
b) Device diagnostic display and System diagnostics upto module level should be possible from the diagnostic software. The details of system diagnostics are described under para 5.4.5 of this specification.

5.5.15 Any special diagnostic package, in addition to as mentioned under para 5.4.5 of this specification, if available with the system shall also be offered. Detailed description and capability of this package shall be supplied.

5.5.16 C&M Printer shall be used for printing the configuration or configuration changes, printing system alarms as and when they appear and to print out any engineers command from Engineering console. Hard copy unit, when specified, shall be used to take hard copy of the engineers console screen.

5.5.17 The system shall have adequate security features to secure plant operation and DCS data base. Engineering console shall have the following security features, as a minimum;

a) Key-lock or password protection for accessing operator functions and engineering functions.

b) Redundant disc and RAID-5 controller configuration

c) Disc interface to enable 'disc down loading' / database or configuration data back-up.

d) Defuncting / inhibiting all functions other than those functions which are required for engineering and operation as defined above.

5.5.18 System Back-up and Re-initialization

a) The entire control software including control database (application program), system software, source code, schematics etc shall be backed up on system hard disc automatically at a regular interval.

b) It shall be possible to have a complete back-up of system including the historical data on-demand without interrupting the system normal function.

c) It shall be possible to have back-ups on remarkable media like CD-RW, DVD-RAM or DVD-RW.

d) The maximum time acceptable for reloading a device like console is five (5) minutes.

5.5.19 Global database Management and Configuration

5.5.19.1 System configuration software shall provide a common database configuration environment and shall support the following data management facilities, as a minimum;

a) System design shall follow the data centric approach and shall manage entire system data in global manner. Paths and connections between data objects shall be automatically maintained when configuration is changed.
b) Whenever the offered system maintains multiple data bases, the design must ensure a close coordination between these data bases such as management of cross reference table and data reconciliation algorithms.

c) Configuration of operator graphics including management of change tools so that the changes made in graphics are updated uniformly throughout the system.

d) All control historical trend function configuration and interconnection between data elements in the system without any need to maintain user based cross references.

5.6 Communication sub-system

5.6.1 The communication shall be a digital communication network bus, that provides a high speed data transfer rapidly and reliably between the operator consoles, process I/O devices, process computer and other devices connected to it. Each network node shall be capable of communicating with other nodes over the communication network.

5.6.2 The Communication network topology shall preferably be bus structure. Other vendor standard topologies shall also be acceptable provided these meet all the functional requirements specified in this specifications and in the material requisition.

5.6.3 The communication over the communication network shall not be affected even if a node connected to network is powered down or fails to respond. It shall be possible to connect or disconnect a device from the system without disturbing the operation.

5.6.4 The communication sub-system shall be dual redundant, consisting of two separate communication networks and two separate communication system interfaces for each device. The systems requiring traffic directors shall be avoided. However, if unavoidable, dual redundant traffic directors shall be provided.

5.6.5 Design shall ensure that there is no cause of common mode failure in communication sub-system.

In general, both the communication networks / devices shall be active at all the times in such a way that either they shall take the communication data load or switch the communication path at regular interval whenever vendor standard data transfer technique allows data transfer to one network while redundant network takes control on the failure of the main network fails. Vendor shall ensure that there shall not be any system degradation or data loss before, during and after the changeover.

Redundant communication network and communication components / modules shall be continuously checked for their availability and healthiness. In case of main bus failure or any communication device failure, the transfer to the back-up device or bus shall be automatic without interrupting the system.
operation and without any operator's intervention. Information about the failed device / bus shall be displayed on the operator console.

5.6.6 Communication network protocol used within the system shall safeguard against false date transfer and allow error detection, recovery failure detection and initiatives of switchover to the redundant network / network component / module.

5.6.7 In addition to automatic switchover of communication network on detection of failure of active / one of the network / network device, it shall be possible to switch over the communication from main bus to the redundant bus manually without disturbing the system operation. Manual switchover shall be effected whenever the network integrity and switchover is to be verified during testing.

5.6.8 The mechanism used by the communication system for error check, parity error, over-run error etc and other advanced codes.

5.6.9 In general, the transmitting message shall identify the transmitting the receiving device. The transmitting device shall receive a reply from the receiving device on the receipt of correct message. Lack of response shall be considered as a receiver failure. These shall be positive acknowledgement of all messages transmitted over the communication network.

5.6.10 Communication speed on the communication bus shall be sufficient to update the operator console data base once in every second. The overall system performance shall not be degraded whether communication sub-system is 10% loaded or 100% loaded. Degradation of communication bus shall be as defined under para 2.18 of this specification. Failure of one or more nodes shall not degrade the communication performance in any way.

5.6.11 Network Diagnostics

5.6.11.1 Network management software shall be resident on all the network modules in order to ensure reporting of node status to other network nodes and reporting node failure alarm within one second.

5.6.11.2 Communication network diagnostics shall run continuously so that the failure of any network / network component / communication module is alarmed without any delay.

The diagnostics sub-routines shall detect and isolate faulty network component and noisy network cables. Communication shall automatically transfer to the redundant component/ module / network whenever the failure is detailed without interruption of system operation and loss of data.

5.6.11.3 Diagnostic sub routines shall be available to monitor the network performance and generate an on-demand report of all the accumulated number of errors over a specified time period.
5.6.12 Network Components and their Requirements

5.6.12.1 All hardware like network cables, connectors, media converters, network switches and hubs and fibre-optic patch-cards required for completing communication network shall be supplied by the vendor.

5.6.12.2 Network can be either screened twisted pair copper and / or fibre optic cable. All network cables shall be armoured type. Fibre optic cable in addition shall be jelly filled for protection against ingress of moisture.

5.6.12.3 Communication network if routed outside the control room shall be fibre optic type only and shall support the use of media converters for fibre optic network. The system design shall allow the use of unequal network lengths in case of redundant network configuration to make-up for the difference in routing lengths.

5.6.12.4 Type and specifications of the fibre-optic cable shall be decided by vendor based on the distance, bandwidth required for data transfer and allowable signal attention. Minimum two number of spare fibres shall be provided in fibre optic cable.

5.6.12.5 Fibre optic cable shall always be routed in enclosed HDPE conduit with matching fittings. HDPE conduit shall be as per IS-4984 or as per equivalent IEC code. The outer sheath colour of HDPE conduits shall be orange with black for the fittings throughout the fibre optic cable run.

5.6.12.6 The network devices such as network switches, media converters, connectors etc, utilized in communication sub-system shall be of industrial grade type and of rugged design. These components shall be selected as per the make and model number listed in the vendor standard product guide.

5.6.12.7 The network switches used shall have multiple speed ports (10/100/1000 MBPS) and shall have;

a) Multi-processor design for high performance operation.

b) Routine diagnostics to detect and isolate noisy cables and jabbering nodes.

5.6.13 Network Loading and OPC Server

Worst-case network loading for the systems supporting determinable protocol shall not exceed 50% while for non-determinable protocol shall not exceed 15%.

5.7 Open System Connectivity

5.7.1 The system shall be capable of interacting with other plant systems and computers over a well established communication network like ethernet (HSE) conforming to IEEE 802.3. This connectivity with the other systems shall always be made via a firewall.
5.7.2 The system software shall be support industry standards like Windows, OSF/MOTIF, TCP/IP etc. as applicable.

5.7.3 The method of data access by any user on this network shall be by I/O Tag name and not by any physical or logical address.

5.7.4 Whenever the communication network is required to connect to any other system network or to plant information network, fire-wall (hardware and software) and routers shall be used.

5.7.5 The system shall be capable of acting as a Dynamic data Exchange (DDE) or OPC client or server to exchange real time data with DDC or OPC compliant application.

5.7.6 When OPC is used for interfacing, system shall exchange the data with any client's application in the standard OPC format. Design shall ensure that OPC connectivity tools are fully integrated within the standard product providing seamless integration. Following shall be ensured;

a) System shall provide alarm and event information with no point building from other OPC alarm and event server directly into DCS system alarm summary.

b) Allows OPC data access clients to view DCS system data, hierarchical area, point and parameter structure.

c) Allows access to historical data from DCS.

d) Allows third party OPC server information to be mapped, displayed, alarmed, get historical data and controller data into the system server.

e) Integrates supervisory monitoring, alarming and control data between two or more OPC servers.

f) All graphic applications and all control function blocks supported by operator console software shall have direct access to data integrated with DCS via OPC.

5.7.7 OPC Server

5.7.7.1 Vendor shall offer integrated or dedicated OPC server in a high grade minimum RAID 5 Configuration only. This node in no way restricts the data transfer. In any case, the device shall be intelligent with adequate memory and software capabilities.
5.7.7.2  OPC Data Access (DA) Server

a)  OPC data access server functionality shall allow bi-directional data transfer between multiple OPC data access servers for monitoring, alarming and control. DA server shall read and write process data using item ID as identifier.

b)  Rate of data transfer in case of DA server is typically 1000 tags per second.

5.7.7.2.2  OPC Historical data access (HDA) Server

a)  OPC client shall access DCS data by connecting to HDA server. It shall also automatically save instantaneous data acquired from DA server and A&E server to be a historical database in HDA server.

b)  HDA server shall be able to receive and publish data timely and efficiently whether online or from archived source. System shall be able to read raw data at the rate of 1000 tags per second and read manipulated data at the rate of 100 data per second.

5.7.7.2.3  OPC Alarm and Event (A&E) Server

a)  OPC A&E server shall publish DCS alarm and events to OPC clients. The server shall support event types such as conditions, tracking and simple events (e.g. component failure). It shall also publish DCS alarm and event such as process alarms, alerts, messages, event, sequence of events and operator changes.

b)  OPC A&E server shall write the following messages to DCS, as a minimum;
   i)  System and process alarm messages
   ii) Mode change and status change message
   iii) Sequence message
   iv)  Operator guide message
   v)   OPC server alarms and errors
   vi)  Engineering maintenance messages

c)  The maximum number of alarms and events received by OPC A&E server shall be of the order of 1 A&E per second.

5.7.7.2.4  OPC Batch Server

OPC batch server shall read and write the batch related data and information of DCS.

5.7.7.3  The OPC server software shall have the following features, as a minimum;

a)  It shall meet support standard OPC standard interface functions such as DA, A&E, HDA, Batch and security as specified by OPC foundation.

b)  The software shall be able to interact with another OPC compliant software loaded in another Third party server machine associated with different make of DCS or control system without the need of any additional hardware or / and software.
c) The software shall support automatic data back-up in such a way that process data acquired by DA/A&E server are automatically saved as back-up data on a disc without client having requested to save the data by server.
d) The software shall allow viewing of contents of OPC server from OPC client.
e) The software shall have capability to restrict the access of OPC server to its client to avoid exceeding the maximum accessible data to avoid load concentration which may slow down the data access.

5.7.7.4 System Sizing

Following criteria shall be followed for sizing OPC notes;
a) Number of third party OPC servers / nodes (This shall include UHN connected to other DCS systems) shall be minimum 10. Ten (10) concurrent licenses shall be supplied as part of OPC node.
b) In addition to third party servers, consider the following;
   Number of client per OPC node : 10
   Number of third party OPC devices : 10 (when specified)
   Such as RTU’s
c) Follow up rate of data read / write shall be considered for sizing;
   OPC client data read (cache read) : 1000 per second
   OPC client data read access (Device) : 500 per second
   OPC client write : 500 per second
d) Maximum number read and write data for OPC node : 2000 data points (unless otherwise specified)

One data point shall include PV, MV, SP for analog control loop.

5.7.7.5 System performance

OPC node shall meet the following performance requirements;
Data read and write on client machine : max. 5 seconds
(This includes data display update for real time data)
Data read and write on server machine : max. 5 seconds
Maximum server loading : 50%

5.7.7.6 OPC node configuration shall be minimul RAID -5

5.7.7.6.2 OPC node shall be supplied with operating system and other softwares to meet functional requirements specified herein.
5.7.7.6.3 Whenever OPC node is provided with historisation or dedicated, it shall have RAID 5 configuration.

5.7.7.6.4 The system when specified, shall offer a standalone software application that provides OPC server redundancy by transparently redirecting client requests to secondary OPC server when primary OPC server is unavailable or fails.

5.8 Time Synchronization

5.8.1 The system shall have capability to synchronize the time of all the sub-systems within the system either by internal or external clock as specified in the job specification.

5.8.2 Time Synchronization with Internal clock

Unless specified otherwise, all the sub-system node clocks shall be synchronized with designated system master clock. Master clock shall either be assigned automatically by system or assigned manually during system configuration. In both the above cases, whenever the master clock node fails, an alternate sub-system clock assumes the charge of time synchronization. In no case, the system shall operate without time synchronization.

5.8.3 Time Synchronisation with External Clock

a) When specifically indicated, the time shall be synchronised with external time reference eg GPS. This shall ensure that data acquired by all sub-systems will have the same and common global time reference. All hardware and/or software required to meet this requirement shall be supplied by the vendor.

b) In general, the system shall be provided with an external GPS antenna connected to a master clock server. This server shall synchronise all DCS clocks and also provide time synchronising outputs to synchronise all non-DCS sub-system clocks. The node shall not exceed 30 millisecond time difference between GPS and any node clock come.

c) In case of failure of master clock server the time synchronisation shall be carried by the designated DCS master clock.

5.9 Shutdown Sub-system - Programmable logic controller (PLC)

5.9.1 Programmable logic controller shall be microprocessor based system which shall be used to execute all the process and safety shut-down logic of the plant when specified, it shall also execute plant interlock logics as well. Programmable logic controller shall be an independent unit and shall not depend on any of its functionality on any other system including Distributed Control System.

5.9.2 The system shall be designed fault tolerant and shall utilize high quality components of proven quality. Any single system fault shall not degrade the system safety or functionality of effect operation. The
system shall have certified Safety Integrity Level as per IEC-61508 / 61511 as applicable and specified in job specification. Unless otherwise specified it meet the availability requirement specified in Clause 5.1.3 of this specification.

5.9.3 The system shall have a very high noise immunity in order to ensure safe and reliable operation when subjected to electrical radio frequency interference and Electro-magnetic disturbances expected in a plant.

5.9.4 Unless otherwise specified, the scan time of programmable controller shall be of the order of 250 milliseconds. Scan time for a PLC shall be as defined under para 2.21(c) of this specification.

5.9.5 Operation of PLC shall be completely unaffected by a momentary loss of power of the order of 20 milliseconds.

5.9.6 On line replacement of any module of programmable logic controller shall be governed by Clause 5.1.6 of this specification in general. However, in case of Triple redundant, Quadruple Modular Redundant (QMR) configuration, Flexible Modular Redundant (FMR) configuration, Virtual Modular Redundant (VMR) configuration there shall not be any process upset while replacement of failed module.

5.9.7 It shall be possible to Hot swap any faulty system module without degrading the system safety or operation or freezing the output status. The switchover to the healthy module shall be bumpless. The swaped module shall take over the function of the failed module without any manual programming.

5.9.8 The system shall be programmed in principle as per the logic diagrams furnished during detail engineering. Vendor shall prepare their own Logic/Ladder diagrams depending upon the capability of the programmable logic controller offered by them. Owner / Consultant reserves the right to revise or review the logic diagrams even after acceptance of any offer. The programming language of offered PLC shall be as per IEC 61131.

5.9.9 Whenever the requirement of SIL is specified for the, it shall meet the requirements of SIL level specified and shall be certified by an independent body (e.g. TUV) for complying requirements of IEC-61508 / 61511 as specified. For shutdown application requiring SIL certification, PLC shall always meet SIL 3 requirements.

5.9.8 Power supplies in the system shall be provided as follows:

5.9.8.1 Each I/O rack shall have a separate independent power supply system. Each power supply shall be sized to take full load of the I/O rack/signal conditioning panel/rack and shall be provided with dual redundant power supply.
5.9.8.2 Each processor shall be provided with separate power supply. Failure of one power supply shall not affect the system operation in case of dual processor system. Wherever triple redundant system is specified each processor shall preferably be provided with a separate power supply. Also separate power supply must be provided for each multiplied process I/O channel.

5.9.9 System Architecture

5.9.9.1 General

a) PLC system configuration / architecture shall be as specified in the job specification. For emergency shutdown system application specified with SIL 3 classification, the system configuration shall be TMR, QMR, FMR or VMR.

b) Regardless the action feature selected (except for single architecture), the failure of single component shall not result in a failure of correctly executed safety function. The degradation mode for the selected configuration e.g. 3-2-0 or 4-2-0 or 3-2-1-0 etc. shall be documented in SIL certification report.

c) In general, the PLC system shall comprise of various sub-systems as described in the subsequent clauses of 5.9.9.

5.9.9.2.1 Input/Output system

5.9.9.2.2 Each I/O module shall have its own processor working asynchronously w.r.t control processor and other I/O processors. However, I/O modules configured in redundant configuration, shall have their processors properly synchronized.

5.9.9.2.3 Unless otherwise specified, system shall accept analog 4 – 20mA inputs and contact inputs. The maximum number of Input/Output per I/O module shall be limited as per the following table.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type of Configuration</th>
<th>Maximum No. of I/Os</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Single I/O system</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Dual I/O system</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>Triple Modular Redundant system (TMR)</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>Quadruplicate Modular redundant System (QMR), Virtual Modular Redundant (VMR) configuration</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>Flexible Modular Redundant (FMR) configuration</td>
<td>16</td>
</tr>
</tbody>
</table>
In case of PLC certified for SIL requirements, the maximum number of I/O's shall governed by the SIL certification applicable for specified SIL level.

5.9.9.2.3 Each I/O shall be galvanically isolated from external control circuit by suitable means. The minimum isolation level between I/O and logic circuit shall be 1000 volts DC.

5.9.9.2.4 Each I/O shall be protected against the reversal of polarity of the power voltage to I/O.

5.9.9.2.5 Each input shall be provided with filters to filter out any noise in the input line and contact bouncing noise, as applicable.

5.9.9.2.6 All the inputs shall be double ended i.e. two wires per input and not with common return for all inputs.

5.9.9.2.7 The interrogation voltage to the inputs and power supply for 2-wise instruments shall be powered from separate redundant power supply / supplies and shall not be a part of PLC, unless otherwise specified. This power supply shall be supplied at one point and shall be distributed by the vendor.

5.9.9.2.8 a) Each I/O module shall have a LED per channel to indicate the status of each Input/Output.

b) When specified, input module shall be capable of monitoring the input contacts for any wire open fault (i.e. 4 – 20mA).

5.9.9.2.9 Analog input module

a) Input module shall be capable to accept input from transmitters (e.g. 4 – 20mA).

b) The module shall have 12 bit A/D resolution accuracy of ±0.25% of full scale over the entire range, unless otherwise specified.

5.9.9.2.10 a) Output contacts from the PLC shall be potential free dry contacts with contact rating as per para 5.9.9.2.10 b) of this specification. Wet contacts/ powered contacts / TTL outputs etc. shall not be acceptable. Vendor must provide arc suppression device for each output contact.

b) The output contact rating shall be as follows:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>APPLICABLE FOR</th>
<th>VOLTAGE RATING</th>
<th>CURRENT RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>All output cards driving solenoid valve and alarm annunciator system unless otherwise specified.</td>
<td>110 V DC</td>
<td>0.5 A</td>
</tr>
<tr>
<td>2.</td>
<td>All motors/pumps/compressor output cards unless otherwise specified. Category – I Category - II</td>
<td>240 V AC 220 V DC</td>
<td>5.0 A 0.2 A</td>
</tr>
</tbody>
</table>

The category of contacts shall be specified in the material requisition.
c) Each output shall be short circuit proof and protected by fuse. Visual indication of fuse blown must be provided for each module.

d) When specified contact output module shall have monitored output features like 5.9.9.2.8(b).

5.9.9.2.11 The communication of I/O system with central processor shall be carried out redundant with complete error checking.

5.9.9.2.12 Where inputs or outputs have multiple field devices for the same measurement or device, the outputs shall be configured in separate I/O modules.

2.9.9.2.13 Where single input signal is available for TMR VMR, FMR, or QMR configuration, inputs shall be multiplied to feed independent inputs to each input modules.

5.9.9.3 Processor system

5.9.9.3.1 The processor shall have capability to implement all the control functions required to implement the logic scheme attached alongwith, as logic/ladder diagram.

5.9.9.3.2 The size of the memory shall be sufficient for storage of the program instructions required by the logic schemes and other functional requirements. Offer shall indicate the amount of memory capacity occupied by the actual program and spare capacity available for later program modifications or additions.

5.9.9.3.3 Memory shall be non-volatile. However in case volatile memory is provided, battery back up shall be provided with a minimum of 3 months lifetime to keep the program storage intact. A battery drain indication shall be provided at least one week before the battery gets drained. A potential free contact shall be provided for hardwired annunciation in the central control room.

5.9.9.3.4 Watchdog timer shall be a software device. The healthiness of processors shall be continuously monitored by watchdog timer. Any hardware or software problem in the processor system, which shall include, CPU, memory, power supply, communication interface etc. shall cause the watch dog timer to report processor failure.

5.9.9.3.5 Wherever Qurd redundant processor is specified, redundancy, shall be provided in such a way that in case of failure of the main processor, the standby shall take over automatically. The changeover, shall be bumpless and the system shall be fail proof, unless any other requirement is specified in the job specifications. Redundancy shall be provided for complete processor system including CPU, memory, power supply and communication sub system.
5.9.9.3.6 In case of triple redundant system all the three processors shall execute the same instructions / programs and check their results and majority vote to correct any faulty result. The faulty processor diagnostic shall be made available.

5.9.9.3.7 In case of VMR, FMR, QMR system, individual processors shall execute the same instructions / programs and check their results within same CPU module and vote to correct any faulty result. The faulty processor diagnostic shall be made available.

5.9.9.3.8 Failure of a single processor in triple redundant system and two processors in quad system shall not affect the system. In case of failure of complete processor system i.e. both processors in case of dual configuration, two or more in case of triple redundant system and more than two in case of quad system, outputs shall take failsafe state automatically unless otherwise specified in the data sheets.

5.9.9.3.9 In case multiprocessor configuration is offered, the processors must be able to communicate with each other over the interconnecting data link. Vendor must ensure that system performance shall not be degraded by any means when such a system is offered.

5.9.9.3.10 It shall be possible to generate the first out alarm contact by the PLC in case where a group of parameters are likely to trip a system.

5.9.9.4 PLC console (Programming)

5.9.9.4.1 The PLC console shall be used for programming, program storing, fault diagnostics and alarm monitoring and should be completely independent of control system(DCS) network /functionality/hardware/software. Whenever specified, it shall also be possible to use this for plant operation. The functionality to operate as engineering terminal or operator terminal or both shall be specified in the material requisition.

5.9.9.4.2 It shall consist of a at least one coloured 21" size TFT screen and one programming / operating keyboard and printer unless specified otherwise.

5.9.9.4.11 PLC console when used for plant operation shall also meet the following functional requirements.

5.9.9.4.3 The keyboard shall preferably be touch sensitive sealed type, easy to operate with each key clearly identified.

5.9.9.4.4 All illegal entries shall be rejected by the terminal and shall be identified by warning signal on VDU.

5.9.9.4.5 Manual forcing of any input or output contact connected to PLC shall be possible from keyboard. Forced functions shall have an associated audit trail.
5.9.9.6 It shall be possible to modify, add or delete the application program on line without affecting the outputs.

5.9.9.7 PLC Console shall display logic and/or ladder diagram indicating power flow and shall show description and status of each contact. It shall also be possible to display process alarms and diagnostic messages as and when they appear. Further it shall also be able to display I/O map in a user defined format.

5.9.9.8 It shall be possible to print out the ladder/logic diagram on the dedicated PLC printer. The printer in addition shall also print out:

a) The diagnostic messages as and when generated and diagnostic reports, when called for.

b) Process alarms connected to the programmable logic controller as and when they appear and alarm report whenever initiated. The choice of printing alarms on this printer shall be operator selectable from a key lock switch on PLC console.

c) The I/O maps showing status of all inputs and corresponding outputs in a user defined format.

5.9.9.9 The PLC console shall be provided with self diagnostics feature which shall display error messages and initiate an audible alarm if the fault is detected. A potential free contact for diagnostic group alarm shall be provided which shall be connected to the hardwired alarm and annunciator system.

5.9.9.10 The system shall be able to identify the failure at least up to the module level including I/O system and redundant processor and report print out.

a) When PLC console is specified, it shall have complete graphic capacity and shall be used for plant operation, process monitoring and control, fault diagnostics, alarm monitoring and report generation.

b) At least three number cursor control devices shall be provided in addition to keyboard which may include touch screen, mouse, track ball etc.

c) PLC operator console shall have complete graphic capability and shall be able to display process dynamic graphics, overview and group view displays. It shall be possible to operate the plant i.e. start and stop of rotating machinery, opening and closing of valves etc. from dynamic graphics and group displays available on PLC operator console.

d) It shall be possible to monitor, historise and print out all process alarms, diagnostic alarms and alarm reports.
e) The time stamping of all alarms shall be as per PLC processor time stamping.

f) The system shall be able to store and display stored data wherever required. The minimum storage capacity shall be for 30 days at 1 minute sample rate for all the inputs specified, diagnostic alarms, process and first out alarms, manipulation data etc.

g) The system shall be able to generate shiftily, hourly, daily, weekly and monthly reports. The log format shall be furnished during configuration.

h) The system shall be supplied with first out alarm generation capability. The resolution of alarm shall be as per processor cycle time.

5.9.9.5 PLC Communication Subsystem

5.9.9.5.1 The PLC communication subsystem shall be a digital communication bus that provides a high speed data transfer rapidly and reliably between the processor, I/O sub-system, PLC console and other devices connected in the PLC system.

5.9.9.5.2 Redundancy in PLC communication subsystem shall be provided as follows unless otherwise specified.

a) The communication subsystem between PLC processor and I/O subsystem shall be single unless otherwise specified. This shall include single communication bus and single interfaces/buffers.

b) For the triple redundant system, each processor shall have a separate set of PLC communication subsystem.

c) For the QMR, VMR, FMR systems each I/O subset shall have separate communication interface and bus for connecting to respective CPU module.

d) The communication subsystem between processor subsystem and PLC console shall be dual redundant, consisting of two separate communication interfaces and two buses, each one configured in redundant mode, unless this is only used as programming aid.

5.9.9.5.3 The mechanism used by the system for error checks and control shall be transparent to the application information / program. Error checking shall be done on all data transfers by suitable codes.

5.9.9.6 Interface with Distributed Digital Control System

5.9.9.6.1 The PLC shall be required to be interfaced to the offered Distributed Digital Control System bus. A suitable interface shall be offered in order to achieve the following functions:
a) Display of all input points under alarm/first out alarm connected to PLC or generated by PLC on the main operator console.

b) Generate shutdown reports on the logging printer of Distributed Digital Control System.

c) To receive certain operational commands from the operator console for the operation of certain output devices connected to PLC.

d) To display diagnostic messages of PLC.

5.9.9.6.2 In general, PLC shall provide data in a well established protocol format preferably MODBUS protocol.

5.9.9.6.3 The interface shall be dual redundant unless otherwise specified meeting all requirements as specified under para 5.9.9.5.3 and 5.9.9.5.4 of this specification.

5.10 System software

5.10.1 The system software shall include all programs for the PLC and PLC console which are required to perform all PLC functions including communication and self-diagnostics.

Whenever PLC is specified for shutdown application with SIL classification, the system shall be designed and engineered in full compliance with the requirement of IEC-61511.

Whenever different functional logics are combined within a common PLC, the safety related I/O's of each functionality shall be kept segregated within the system.

5.10.2 Logic program shall be recorded on the CD which shall be delivered in duplicate together with the system.

5.10.3 The PLC programming language for implementation of logic operations shall be based on the following representations:

a) Logic diagrams - Binary logic symbols such as AND, OR, NOT Gates, Timers and Flip-Flops.

b) Ladder diagram - Series parallel connection of relay contacts.

c) Combination of (a) & (b) above.

5.10.4 It shall be possible to print out the ladder/logic diagram on a dedicated printer. The printer shall also print out all diagnostic reports. Vendor must supply the off line software package to enable the owner to modify/add/delete any part of program and for documentation.
5.9.10.5 Software for the generation of various displays including dynamic graphics, whenever specified, to be provided as per para 5.4.3.5 of this specification.

5.9.10.6 The software for printing alarms, system as well as process and events on the PLC printer must be provided. All alarms must be printed as and when they appear.

5.9.10.7 Software package for displaying I/O map showing status of inputs and corresponding output as per logic shall be offered. The I/O map format shall be users definable.

5.9.10.8 The system shall have an extensive set of self diagnostic routines which shall be able to identify all permanent and transient system faults / failures at least up to module level including redundant components and power supplies through detailed VDU displays and report print out. Diagnostic software shall have the capability to provide information about the failed module/system either in the form of a system configuration display or provide information in the form of a statement.

5.9.10.9 System for the following functionalities shall be supplied when specified;
   a) Long storage historisation
   b) Log report generation
   c) First out alarm generation

5.9.10.10 System diagnostics shall be capable of identifying, locating and reporting the following faults, as a minimum;
   a) Processor fault
   b) Communication fault
   c) I/O module fault
   d) Power supply fault
   e) Over temperature monitoring
   f) Permanently close / open (stuck on or off) fault
   g) Scan time failure
   h) Memory fault
   i) Signal redundancy fault

Any other additional diagnostic alarm if available as standard shall also be provided by vendor.

5.9.10.11 Self diagnostic software shall have capability to detect faults which make the system permanently close/open in the I/O modules or I/O signal conditioning modules (incase of triple redundant system, whenever specified in the job specifications, this may be achieved by automatically running the testing software at cyclic intervals) The automatic cyclic testing feature shall also be provided for dual I/O configuration and dual I/O signal conditioning for triple redundant system. The testing software cycle
time may be considered one in 30 minutes however this shall be field adjustable by engineer. However, system performance shall not be degraded whenever testing feature is specified.

5.9.10.12 In case of triple redundant system or quadruplicate system, whenever output module testing software detects any faulty channel, the power supply to that particular module in that particular bank is removed automatically and further testing on the corresponding module in the other mirror image bank is stopped. However, the testing continues uninterruptedly in other output modules.

5.9.10.13 Feedback must be provided in case of triple redundant system and quadruplicate system from the output voter system to detect any latest faults of the system in addition to other diagnostic software as per para 5.9.10.9 through 5.9.10.10 of this specification.

5.9.10.14 Diagnostic package and its related equipment and software shall be supplied. A list of additional diagnostic packages available and the packages provided, including the description and capabilities, shall be provided with separate quote.

5.9.11 Sequence of Event (SOE) Function Requirement

Sequence of Event for analog and digital inputs shall be generated and time stamped in PLC. The maximum resolution between two events shall not exceed specified PLC scan time unless specified otherwise. A separate SOE PC with 21" size TFT screen and laser printer shall be provided for each PLC sub-system unless specified otherwise.

5.10 Foreign Device Interface

5.10.1 Foreign device interface shall be capable to transfer data from the foreign devices like analyser systems, gas chromatographs, gas turbine system etc. to other sub-systems connected to communication sub-system and vice-versa wherever specified in the job specifications.

5.10.2 Each device interface shall be redundant unless otherwise specified in job specifications.

5.10.3 Interface hardware and software shall be suitable to match the foreign device communication requirements like hardware interface, communication protocols etc.

5.10.4 While writing software or mapping the input/output in the interface device it must be ensured that integrity of the data to be transferred like resolution, correctness etc. shall be maintained.

5.10.5 Redundant interface switchover shall be designed based on the type of redundancy available in the foreign devices.
5.10.6 The total responsibility of selection of hardware, writing of software, switchover of redundant interface etc. shall be of distributed control system vendor only. All necessary information, assistance and help shall be rendered by the Foreign device vendor.

5.10.7 The exact requirements of Input/outputs to be transferred shall be as per job specifications.

5.11 **Interface with Smart Transmitters**

5.11.1 System shall be provided with suitable hardware and software to interface with the communication protocol of specified smart transmitters.

5.11.2 In case, smart transmitters are specified with 'HART PROTOCOL', the maintenance data related to these transmitters shall be made available on a separate Personnel Computer. The system shall meet the following requirements as a minimum :-

a) The system shall allow the maintenance functions like configuration, calibration and monitoring of transmitter's data from the associated personnel computer in addition to Hand held terminal, whenever used.

b) The hardware used shall allow unrestricted transfer of digital signal without degrading the analog data i.e process variable.

c) The software supplied shall be 'CORNER STONE' OR EQUIVALENT compatible with the specified transmitter protocol. The software shall allow the following data to be displayed on the PC:-

   (i) Complete configurational data base of all transmitters including data of commissioning, last calibration, next due calibration etc.

   (ii) Historical data for calibrations and configuration changes.

   (iii) Event and log reports.

   (iv) Multiple authorisation levels for carrying out Configuration changes and Calibration adjustments.

   (v) Manual editing of data base with Password and /or keylock protection.

5.12 **Hard-wired Instrumentation**

5.12.1 Hardwired instruments shall be stand-alone type and shall meet their functional requirements fully without depending on DCS system. Even power supply and input/output circuits of hardwired instruments shall be totally independent of DCS system.
5.12.2 Hard wired instruments shall be microprocessor based. Each instrument shall have as a minimum the necessary firm-ware to meet its functional and operational requirements.

5.12.3 Each device shall have its own analog to digital/digital to analog converter.

5.12.4 The display of each device shall preferably be bar graph type.

5.12.5 Controller shall be digital type capable of performing automatic control based on the set points given locally or from a remote device like another controller or Distributed Control System or Supervisory computer. The controller as an instrument shall also have provision for manually controlling the process by means of a manual loader and cascade-computer auto-manual transfer switch. The operation of the transfer switch shall be procedure-less and bumpless while changing mode from computer to cascade to manual and from manual to auto to cascade to computer. During such a change the output shall not change by more than 1% of span. Controller shall have a facia giving continuous indication of process variable, set value, controller output, and controller mode. It shall be possible to remove an instrument for maintenance without upsetting the process by use of device like service station. Operation of the controller like set point change, manual control, controller mode change shall be possible from the front of the controller. Controller shall be flush panel mounting type on the panel/hard wired console. Configuration and tuning of controller shall be possible through a portable and pluggable configurator.

5.12.6 Recorder shall have independent circuit and pen drive assembly for each channel. Recorder shall have capability of continuous line marking or digitized marking of input value with high resolution. Recorder chart drives shall be of multi-speed type and shall be operator selectable. Recorders shall be flush panel mounting type on the panel/hard wired console.

5.12.7 Manual loader unit shall have continuous display of process variable and manual loader output. It shall be possible to manually change the output to control valve. Manual loaders shall be flush panel mounting type on the panel/hardwired console.

5.12.8 Temperature transducers and trip amplifiers shall accept inputs from standard industrial thermocouple and resistance temperature detector (RTD). Linearization of the thermocouple and RTDs shall be done inside each instrument. Transducers and amplifiers shall be suitable for rack mounting.

5.12.9 Alarm cards shall accept standard outputs and shall produce changeover contact output. Each alarm card shall have one continuously adjustable blind setting device. Alarm cards shall be suitable for rack mounting.
5.12.10 Alarm and annunciator system

5.12.10.1 The alarm logic shall be executed in single input plug-in type logic modules. Where integral logic has been indicated, the logic module shall be accessible from the front of the annunciator after opening the swing door. The design of each module shall be such that by simply jumpering suitable point, it may be changed from normally open mode of operation to a normally closed mode of operation and vice versa.

5.12.10.2 Lamps shall be replaceable from the front. The power consumption of each lamp shall be approximately 10 watts.

5.12.10.3 The initiation of alarm condition in the annunciator shall take place approximately 330 millisecond after the condition sensing contact have assumed the off-normal state.

5.12.10.4 Hooter, in general, shall be solid state type with audibility of the order of 100 dB at a distance of 3 metres.

5.12.10.5 An interruption of power supply for a duration of 20 milliseconds or less shall not affect the functioning of the annunciator.

5.13 Instrument Asset Management System (IAMS)

5.13.1 Instrument Asset Management System shall facilitate the maintenance management of all smart, field-bus based and conventional field instruments. Unless otherwise specified, the system shall manage the maintenance of following;

a) All smart and field-bus based instruments connected to Distributed Control System or Programmable Logic Controller.

b) Conventional (non-smart / non field-bus) instruments connected to DCS or PLC or any other dedicated instruments.

c) Field Instruments other than (a) and (b) above eg. local gauges etc.

5.13.2 The system shall include all hardware and software to meet specified functional requirements. In general, IAMS shall be an integral part of Distributed Control System and shall acquire the data from the controller and data acquisition sub-system. Inputs, which are connected to programmable logic controller, shall be parallely connected to DCS in such a way that the hardware used shall allow unrestricted transfer of digital signal without degrading the analog signal.

5.13.3 A dedicated IAM console consisting of one video display unit along with a printer shall be provided;

a) Display all data related to device diagnostics.

b) Provide historical data for calibration and device configuration / reconfiguration etc.

c) Generate event and other device reports.
d) Manual data entry with password / key lock.
   
   The VDU shall be 21" colour TFT monitor along with a keyboard and a printer.

5.13.4 The system shall support multiple authorisation levels for carrying out configuration charges and calibration adjustment.

5.13.5 The Instrument Asset Management System shall meet the following requirements:
   
a) Instrument Configuration
   
   It shall be possible to configure, verify the configured parameters, reconfigure, re-range and calibrate / recalibrate the smart and field-bus devices from IAM console.

b) Device Status Monitoring
   
   The system shall monitor the status of all field devices and shall report any maintenance alarm generated by these devices. In general, following shall apply;
   - Diagnostic alarms from smart and fieldbus devices shall be classified into device failure and device diagnostic categories.
   - Out of limit alarm shall be generated to indicate device failure alarm for conventional devices.

   The system shall be capable of displaying and generating maintenance report listing all devices currently under alarm. The report may be generated unit-wise / area-wise or for complete plant.

c) Maintenance database
   
   The system shall be able to maintain maintenance database for all the instruments which shall include date of commissioning, last calibration date, next due calibration. The system software shall have capability to manage and track scheduling of all such maintenance related activities.

   The software shall also provide data as predictive maintenance such as list of transmitters experiences excessive drift, list of control valves loosing on shipping characteristics etc.

d) Audit Trail
   
   The system shall have capability to provide an audit trail for a complete historical record of all configuration, calibration and device alert data. This shall include tracking of maintenance history for all instruments in the plant, typically recording the type of maintenance work done, smart and compilation times of activity, person responsible for the activity etc.

e) Advanced diagnostics
The system shall be able to provide advanced diagnostics such as device step response, device signature, dynamic error band etc. special device diagnostic software whenever required (like for smart / field-bus position) shall run in the system.

f) Documentation

System shall generate documentation like trend reports, diagnostic reports, pre-detective maintenance report, audit report, historical data and device specification sheet etc. Definition, engineering, configuration, loading and completion of all reports whether specifically indicated are available as standard and shall be supplied as part of vendor scope of supply.

5.14 Alarm Information Management System (AIMS)

5.14.1 The purpose of Alarm Information Management System (AIMS) is to provide a centralised Alarm information over and above the requirements specified in Clause 5.4.3.8 of this specification and shall be used for acquiring, sorting, add value and provide redistribution platform, so as to streamline and transform the raw alarm data into intelligent, add actionable information for plant operation personnel.

5.14.2 The system shall acquire inputs from various systems such as;

- Distributed Control System / Systems and Programmable Logic Controllers.
- BMS, STG control System and F&G Systems
- Package unit control systems
- Machine monitoring and Analyser system
- Electrical control system / systems
- Electrical numerical relays
- Any other system defined specifically in the job specifications.

5.14.3 Unless otherwise indicated, the AIMS shall have a high speed data transfer OPC link connectivity with the systems. Where OPC link is not available, the data transfer shall be through dedicated serial links. In addition, AIMS shall also have capability to accept hardwired inputs.

5.14.4 Unless otherwise specified, the following type of data shall be acquired by the AIMS software for further analysis;

- Process and utility alarms
- System diagnostic alarm
- Sub system status alarms
- Operator activities
- Maintenance alarms

The AIMS shall offer a variety of alarm handling feature for processing, and presenting alarms in most efficient way. The package shall be a comprehensive tool with capabilities of;

a) Logical filtration of alarms during normal and special operating conditions such as start-up, process upset and turndown conditions.

b) Logical processing of events and sequence of events for facilitating quick assessment of normal or emergency situation based on pre-defined rule-sets.

c) Generation of different levels of alerts, based on type of alarms, sequence of alarms, logical processing of alarms etc. and propagation of the same to different groups and categories of personnel's, based on pre-defined alarm distribution matrix.

5.14.5 AIMS shall meet the following functional requirements, as a minimum;

5.14.5.1 Data Acquisition

The data acquired from the various sub-systems and other control systems shall be stored in a dedicated AIMS server. The data shall be stored in a structured format and shall contain tag number, time of occurrence, text information like service description, event type, alarm priority, alarm group priority etc.

5.14.5.2 Alarm Computing

The package shall have capability to generate / compute alarms based on a logical combination of states, conditions and events.

5.14.5.3 Information Analysis

The package shall have capability to analyse and present only the meaningful information. This shall include the following;

a) Analyse the alarm frequency within the predefined period and its repetition period.

b) Analysis of various alarms to identify nuisance, chattering and redundant alarms and eliminate them, if necessary.

c) Analysis of various alarms to identify serious alarms and monitor their frequency of occurrence.

d) Monitoring Operator actions.

5.14.5.4 Expert Alarming
The system shall be able to carry out statistical analysis on the alarms data gathered and perform;

- Real-time frequency analysis
- Alarm frequency break-up
- Alarm frequency monitoring
- Standing alarms
- Time elapsed between two alarms / events

ii) The system shall have capability of implementing rule sets to analyse various alarms / data and inform plant operator the probable reason, make recommendations for the action to be taken and provide operational alternatives.

iii) System shall also be capable of analysing and recommending maintenance requirements based on preset rules.

iv) The system shall have advanced search and sort features to provide quick access of alarm data to operator.

5.14.5.5 Alarm Prioritisation

The system shall have the capability to segregate the alarms as per their criticality and operational importance, which may be defined as per the severity with respect to its;

- Production losses
- Human and equipment safety
- Environmental safety
- Process reaction time like run-down reactions

The alarms shall be differentiated in different displays by allocating different colour codes.

The system shall be able to be configured with different priority levels which shall be defined based on the process criticality and operational requirements. As a minimum following priority levels shall be definable;

Level 1 - Alarms directly related to human safety – leading to heavy casualties

Level 2 - Alarms directly leading to total plant shutdown – personnel, environmental and equipment safety hazard.

Level 3 - Alarms leading to partial plant trip conditions.
Level 4 - Maintenance alarms not leading to immediate plant trip.

Level 5 - Status or low priority alarms for operator information.

Other priorities shall also be user definable. It shall also be possible to set priority for each and every alarm point. Assignment or change of level of priority shall be possible only under password protection.

Number of alarms under each level of priority shall be user definable. However, for the purpose of internal assignment, following numbers may be considered:

<table>
<thead>
<tr>
<th>Priority Level</th>
<th>No. of Alarms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>10 Nos.</td>
</tr>
<tr>
<td>Level 2</td>
<td>70 Nos.</td>
</tr>
<tr>
<td>Level 3</td>
<td>5% of Total</td>
</tr>
<tr>
<td>Level 4</td>
<td>20% of Total</td>
</tr>
<tr>
<td>Level 5</td>
<td>75% of Total</td>
</tr>
</tbody>
</table>

5.14.5.6 Alarm Display

a) AIMS shall display alarms gathered from all Nodes / subsystems seamlessly and shall be displayed on any display irrespective of source or location.

b) Alarm display shall be sorted out in the form of alarms groups in the following categories;

- Priority level sorting
- Sorting as per type, frequency, unit-wise, area wise and operating area wise.

c) AIMS displays shall be in graphic form with user friendly displays, color modifiers etc.

d) The system shall process alarms using well proven analysis techniques, directly related to specific alarms, which are trendable.

The system shall have advanced Rule-based and latest abnormal condition management tool which shall provide prediction and anticipation of plant deterioration with sufficient lead time for operation action. The system shall also have real time root cause analysis.

5.14.5.7 Operator Actions

The system shall be able to acquire and analyse operation action required during plant operation such as;

- Time to alarm acknowledge
Controller mode changes
Controller set point changes
Analogue output changes (in manual mode)
Discrete output changes (in manual mode)
Alarm level of priority changes
Range changes
Tuning constant changes
System configuration changes e.g. control algorithm, cycle time changes etc.
Manual time adjustment
Alarm acknowledgement
ESD switch actuation (full or partial)
Any other operator action not specifically indicated above but required during operation. The operator actions shall also be categorised based on their criticality in various levels.

Level – 1 - Most critical operator actions leading to plant shutdown in full eg. ESD switch action.

Level – 2 - Configuration changes or set point changes which may lead to mal Operation or partial plant shutdown eg. set point changes, range Changes, time adjustment etc.

Level – 3 - Changes which may effect control but rarely could lead to plant Shutdown full or partial eg. controller mode change, range changes, tuning constant changes etc.

Level – 4 - Actions which are mere operation but does not lead to plant operation.

The system shall also able to provide information like;

i) Time to acknowledge alarms

ii) Alarm acknowledge time exceeding a pre-set value.

5.14.5.8 Report Generation Printing

The package shall have capability to;
a) Store alarm messages for a period of minimum one year and shall have facility for data archival on portable media.

b) AIMS shall be capable of generating and printing reports in user defined formats. The data in each report shall be either raw, manipulated, calculated, compressed or analysed.

c) The alarm shall be possible to be printed as and when required, as a user defined formats. These formats shall be defined during engineering.

5.14.5.9 System Diagnostics

The AIMS shall have extensive set of diagnostic subroutines running in real time basis and shall provide at least the following diagnostic alarms;

- System software failure
- Disc / Disc drive failure
- Application software failure
- Network failure
- Communication software failure
- Disc full
- Power supply failure

These diagnostic alarms shall also be made available at DCS operator and engineering consoles.

5.14.5.10 Data Storage and Archival

AIMS shall store alarms and events indicated in Clause 5.4.6 for a period of minimum 1 (one) year in the hard disc. Multiple disc configuration, if required, shall be provided for the purpose of calculating data storage capacity consider occurrence of 30% of alarm and events per day apart from other system defined functionalities.

5.14.5.11 Alarm Notification and Audio Messaging

The system shall be capable of performing following alarm notification and messaging functions;

a) Dial Telephone

In case of predefined alarm or alert condition the system shall automatically dial a telephone number and plays a pre-recorded message. All hardware and software for auto-dialing shall be included.

b) Dial a Cell phone
The system shall have facility to dial up mobile pager or mobile cell phone. When an alarm occurs, the system shall be able to send a test (SMS) message also.

c) E-mail

When a predefined alarm occurs, the system shall be able to send message through an e-mail to the predefined user. This facility shall also be utilised to send e-mails to the manufacturers of various system oriented items like DCS, PLC etc in case of occurrence of a critical system diagnostic alarm.

d) Audio Messages

The system shall be capable to play a pre-recorded message in case of predefined critical alarms on the plant public address system. For example, this shall be useful for alerting plant personnel's on gas / fire alarm in a particular area.

e) Emergency Hooters

The system shall be capable of generating input such that in case of an emergency condition emergency hooters can be initiated along with audio messages on the public address system.

5.14.6 System Hardware & Software

5.14.6.1 AIMS shall have all the hardware and software to meet the following major functional requirements;

a) Efficient storage and archiving of acquired and manipulated data to allow retrieval of reports or alarm analysis information.

b) Retrieval of important information on-line to a network drive disc or dedicated device.

c) Remote access to more than one clients on the network.

d) Export alarm, events or other information to other applications, Excel or Access.

e) Advanced diagnostic techniques for analysis of acquired data.

f) Log the time between specified alarms / messages.

g) Assignment of various level of pass-ports.

h) Multiple client's displaying different data or data screens simultaneously.

i) Disc mirroring for data storage over the network.

j) Automatic Triggering of alarm reports and messages on devices like mobiles,
telephones, computer networks etc.

k) Data search facilities with efficient search engines like SQL.

l) Data sorting facility as per defined rule-set.

m) Time stamping of data as per AIMS clock wherever required.

5.14.6.2 AIMS can be realised on either the DCS platform or as a stand along system. In either case the offered solution shall meet all the requirements specified in MR without exception.

5.14.6.3 In case AIMS functionality realised on DCS platform a separate dedicated AIMS station shall be provided. This station shall have same hardware and software configuration as operator console and shall have redundant storage disks for bulk data storage.

5.14.6.4 In case stand-alone system is considered, the same shall meet the following requirements;

a) The system shall be capable of interaction with DCS via a serial port or by OPC connectivity.

b) The system shall have a minimum of one dedicated server with monitor and cursor control devices capable of meeting all functional requirements for AIMS. If the system demands more than one server to meet job requirements, the same shall be supported and provided.

c) The AIMS console shall be server based machine and shall have 21” LCD display screen with keyboard, mouse and read / write DVD drive.

d) The system shall support client server architecture with minimum of 4 clients. Detailed functionalities of these clients shall be finalised during engineering. The clients shall also meet hardware and software requirement specified in Clause 5.14.6.4(c).

e) AIMS server shall have redundancy in storage discs for bulk-data storage.

5.14.6.5 In general, all alarms and events shall be transferred to AIMS with time stamped by the originating devices. AIMS shall maintain this time for further analysis. AIMS shall time stamp the acquired data only when this data is not transferred by the originating device with time stamp.

5.14.6.6 The AIMS connectivity to third party devices and systems shall be either from the control network (i.e. communication sub system) or from the serial ports available in these devices. For third party systems direct connectivity from the station having master database is preferred.

5.14.6.7 When multi drop serial link connectivity, not more than four (4) devices shall be multi-dropped on one serial link to server.
5.14.6.8 AIMS shall have sufficient flexibility in hardware and software to interface a variety of peripheral devices, these include but shall not be limited to;

- Printer to be provided and attached to the server or client for printing reports and alarms.
- Public Address system for automatic broadcasting of alert messages in pre-designated areas. (The package shall be supplied with a voice package, which shall automatically broadcast the message as the occurrences of the particular alarm).
- Fixed line EPBAXs and Mobile telephones
- Horn and / or beacons for Audio / Visual alarming.

5.14.6.9 AIMS server memory shall be sized suitably to display and printout the alarm history of all the tags of all the systems and sub-systems connected to it.

5.15 Unit History Node (UHN)

5.15.1 UHN shall primarily used to carryout the following activities;

a) Store automatically gathered data from control system (DCS, PLC, etc), other DCS systems over OPC and manually entered data.

b) Present data in a meaningful manner for performance enhancements and fault analysis.

c) Long term historisation of data for future reference and decision making.

d) Carryout calculations on the real time and stored data, as necessary.

5.15.2 The UHN shall be a high capacity data storage device where data from various process units shall be stored in a fast access database. The node shall support standard open system interfaces like OPC, SQL, OLE, DDE and shall provide active X facility.

5.15.3 UHN shall collect data from;

a) Distributed Control system of which this UHN is a node.

b) UHN's of other control systems

c) Nodes other than UHN's connected on information network.

d) Manually entered data.

The data collected shall be of various types like process variable, set point, computed variable, manipulated data, outputs, alarms, events, which shall be used for long term storage, trending and report generation.

5.15.4 UHN shall have capability of storing real time data in real time database and shall perform functions like;

a) Identification of bad data (algorithm to run in UHN when necessary)
b) Specify dead band and data sampling rate (or collection rate) as user definable parameter.

c) Calculate maximum, minimum, average, summation, and, integrated values of collected data. The time period of calculating average shall be user definable.

d) Specify high / low, high – high / low – low alarm limits for triggering an event or message or alarm as applicable.

e) Specify damping parameter, delay parameter etc. to reject unwanted data.

f) Specify data storage / sampling rate and period of storage necessary for historical storage of data.

g) Mathematical functions and application program as specified in material requisition which are necessary for report generation. (This does not include advanced control functions but do include MIS reports)

All the parameters indicated or functions performed shall be definable tag number wise.

5.15.5 Data Management and data presentation

5.15.5.1 UHN shall act as a network server and shall support two way data communication between;

a) DCS and UHN for real time data transfer. UHN shall acquire real time data from DCS and provide derived and calculated data to DCS.

b) UHN and information network to transfer data from other systems on information network to UHN and vice versa.

5.15.5.2 UHN provides the user with current raw and calculated / manipulated data on predefined graphic screens or pre-defined report formats. The graphic screens and report formats are user configurable.

5.15.5.3 UHN perform long-term historization of raw and calculated / manipulated data.

5.15.5.4 The data received or sent from the UHN shall have time stamp associated with it from the originator of the data. The data update is effected in case the data value has changed by more than the configured dead band since the last update.

For manually entered data, the time stamp shall be time of entering data (by default) or the time entered with the data as applicable.

5.15.5.5 UHN time shall be synchronized with DCS time clock. For time synchronization refer clause 5.8 of this specification.

5.15.5.6 UHN shall maintain relational database and shall support oracle ROBMS tool.

5.15.5.7 All data raw, manipulated or manually entered acquired or calculated by UHN shall be stored, as unit-wide historian. Historian can be accessed to retrieve the data from specified period in the past. Historian should have capability to store data for a period of one year (365 days) with a sampling rate of 30 seconds, as a minimum. Other sampling rates such as 1 minute, 5 minutes, 10 minutes and 1
hour shall also be possible. The duration of on-line storage shall be controlled by the archiving facilities which in turn shall be dependent on specified sampling rate.

5.15.5.8 The data shall be presented to the user in a well structured hierarchically configured user displays. User shall be able to navigate down to any detailed data displays without any system configuration knowledge.

The display structure may include;

a) Overview display or main menu display, displaying key process parameters and performance indicators like real time data, swap-shot, calculated variables, real time trend, historical trends, manual data entry, function block, alarm and events, reports etc.

b) The reports generated shall include both tabular and graphical type (i.e. trend and bar graph). The reports as a minimum, shall include shiftily, daily, weekly, monthly and yearly reports. The report formats and specific data shall be finalised during system configuration stage.

5.15.6 System Administration and Security functions

5.15.6.1 The system shall perform the following administration functions;

a) System start-up and shutdown
b) System configuration and configuration changes
c) System diagnostic alarm management
d) Archiving and storing history data.
e) System back-up and system restoration from back-up.
f) Manning user and security files.
g) Maintenance sub-routines and manipulation of data in the database with Audit.

5.15.6.2 UHN shall provide a full data security guarantee and shall be equipped with proper fire wall security features. For details refer clause 5.1.12 of this specification. Typically firewall shall be CISCO system appliance firewall (PIX) and software (IOS) or equivalent.

5.15.7 System Configuration

5.15.7.1 UHN shall be higher grade RAID 5 server machine with preferably Xeon CPU. The selected UHN hardware platform shall meet system throughput and capacity requirements. As a minimum, the system hardware shall meet the following requirements;

a) VDU shall be 459.7 mm active matrix TFT type coloured LCD screen.
b) QWERTY keyboard with SCSI interfaces
c) Mouse or track-ball control
d) Memory as 1GB RAM and 80GB hard disc (HDD) and shall support DAT and DVD / CD ROM.
e) Clock speed as 2.4 GHZ
f) Coloured laser printer
5.15.7.2 The system shall be supplied with a robust operating system and all supporting softwares necessary to meet functional requirements specified here in including RDBMS such as oracle or SQL with TCP/IP as network protocol.

5.15.8 System Sizing

Following criteria shall be followed for sizing UHN;

a) UHN shall interact concurrently with minimum 10 number of users in addition to DCS (of which UHN is the node) and clients main computer. Unless otherwise specified, ten concurrent user licenses shall be supplied along with UHN node. For the purpose of sizing consider at least 20 concurrent users.

b) The data shall be accessed from remotely located data sources through information network or through auto-dialing with proper ID address and password protection. The rate of data access from/to this network shall be considered as 1000 tags per second.

c) The data access from DCS shall be all 1.4 times the all analog (PV, MV, SV) and digital tags accessed at the rate of 1000 tags per second.

d) UHN historian shall be sized considering following factors;

Storage data : 2 times the total analog (PV, MV, SV) and digital data of all DCS connected tag number (through hardwiring, serial ports, fieldbus etc.

Storage time : 1 year (365 days)

Storage rate : 30 seconds for all data

Storage interval on RAM: 20 minutes

5.15.9 System Performance

5.15.9.1 The response to all online enquiries and actions from any user shall be complied with 95% confidence level from any client with a maximum of 20 concurrent users as defined in clause 5.15.8(a) of this specification shall be as follows;

a) A data query to display on graphic or report : 5 second

b) Pre-defined trends up to 1 hour data : 5 seconds

c) A data query to present a 24 hours report : 10 seconds

5.15.9.2 Average loading shall not exceed 50% when averaged over 15 minutes with peak loading at any time not to exceed 70%.

5.15.9.3 All securities shall be positioned while evaluating system performance.

5.16 Sequence of Event Recorder (SER)
5.16.1 Sequence of event recorder shall be provided for recording sequence of alarms / events for shutdown inputs.

5.16.2 The inputs for sequence of event recording shall be handled as follows;
   a) The maximum number of inputs for I/P module shall be 32.
   b) The contact inputs (either open or close on alarm) shall be multiplied using dual output contact barrier one of which contact shall be connected to PLC while the other contact is routed to SER. Wherever necessary, fast response multiplying relays may be used (certified by SER manufacturer)
   c) For analog input, the signal shall be connected in parallel across the conditioning resistance to PLC or dual output barrier and to a dedicated alarm card, the contact of which shall be routed to SER. In case analog input are to be routed to different physical locations or more than two devices, analog isolators shall be used.

5.16.3 SER shall be capable of providing demonstrable alarm resolution of 1millisecond between the events and shall also be able to print out the same with similar resolution.

5.16.4 The contacts or alarm may be close or open on failure and must be configurable for close / open on failure.

5.16.5 The SER system shall be capable of providing alarm monitoring, printing and inputs for management packages. The configuration of inputs and other functions mentioned above shall be carried out using a dedicated terminal, which is also provided with a printer. Once configured, the access to configuration shall be denied except with 3 level of password protection.

5.16.6 All the trip / alarm settings should be same as that of PLC in all respects. The accuracy and resolution of measurements and settings are to be equal or greater than that of PLC.

5.16.6.7 Vendor shall make a provision to connect PLC outputs to SER recorder whenever necessary and decided during engineering with proper isolation.

5.16.8 There must be 20% installed and wired spare input channels up to the marshalling cabinet for each type of input / output of DCS, PLC and other systems.

5.16.9 The system must have facility of keeping at least 96 hours of record at the time with last in and first out facility.

5.16.10 It shall be possible to configure / modify / reconfigure the system online through a dedicated programming unit. Engineering shall be possible to engineer the system using menu driven fashion. Any addition and deletion of inputs should be menu driven only and should be possible to be done during running condition.

5.16.11 It shall be possible to archive data from the SOE recorder on tape drive / CD drivt. CD driver and CD writer along with all necessary software shall be part of system supply by the vendor. The CD driver and CD writer must be with latest hardware and latest software.
5.16.12 The system shall have an extensive set of diagnostic package, which shall be able to provide the fault alarms up to the module level. The same shall be also printable on the laser printer. The system shall be able to generate an audit report, which can be printed on demand. The audit report shall be able to provide shutdown area, time of shutdown and reason for shutdown.

5.16.13 Sequence of events shall also record PLC shutdown outputs.

5.17 Large Screen

5.17.1 The Giant Screen (Large screen) in the control room, is primarily used for:

a) Display important operational data of the plant/unit for ready reference like daily production, shutdown required/requested etc.

b) Display operational situations like start up or shutdown to enable managers/operators to discuss without disturbing the unit operator.

c) Display any operator screen on the large screen.

d) To provide real time clear luminous view of the unit to share information’s between operators, unit managers and refinery manager.

e) To hold demonstrations to visitors for ready impressive and effective plant overview and plant highlights.

5.17.2 The giant screen shall be installed in the control room wall. The size of the screen shall be approximately 3200mm(L) X 1300mm(H) as a minimum.

5.17.3 The giant screen system shall have the following specifications:

i) The screen design shall be based on single chip DLP technology.

ii) Optical system shall have a resolution of 1024 pixels X 768 pixels Colour pixels per cubic. Each cube shall have a screen diagonal of 70 inches with 16.7 million colours.

The lamp shall be pre-adjusted in lamp module, which shall not require any readjustment after replacement. The minimum operational time of lamp shall be 8000 Hrs.

They shall be able to provide uniform brightness of 95% with a contrast 250:1, which shall be able to provide high contrast even in bright ambient light.
iii) The display screen shall be seamless and flicker less. It shall be black or grey in colour. The brightness and contrast shall remain uniform irrespective of the number of cubes used.

iv) The control of screen displays shall be carried out either from the operator console. The signal transfer shall provide guaranteed disturbance free operation, which shall not affect sharpness and colour quality.

v) The giant screen shall be lightweight and low-thickness type, which can be supported from the control room wall. Only the front access shall be provided for any maintenance.

vi) The system shall perform satisfactorily in ambient conditions with maximum temperature of +40 degree Celsius and 80% non-condensing humidity.

vii) Provision of automatic switch off of Giant screen if temperature in the console room increases above the maximum permissible limit for Giant screen is required.

viii) VDU shall be provided with the Giant screen Control station. Ethernet card shall be provided in Giant Screen to connect it with Ethernet port for necessary functionality.

5.17.5 The Giant screen system shall be interfaced with the system such that any operator display of any screen could be displayed on the Giant screen suitably. It shall meet the following requirements;

i) Any operator console display or all operator console displays shall be able to be displayed or switched as desired.

ii) Screen areas should be protected for each console group.

iii) Priority of displays should be assignable.

iv) The system shall be supplied complete with all hardware and software as necessary for the specified application including interface software for DCS.

6.0 MISCELLANEOUS REQUIREMENTS

6.1 Safety requirements

6.1.1 Unless otherwise specifically indicated in job specification, all the equipment covered in this specification shall be located in general purpose non hazardous area, normally in control room or / and satellite rack room. However, transmitters, process switches and final control elements including smart positioners, solenoid valves etc. I/P converters (not forming part of this specification) shall be located in the field and shall be specified as per the electrical area classifications.

6.1.2 Unless otherwise specified, intrinsically safe certified transmitters, smart positioners, field-bus devices, and I/P converters shall be used when located in hazardous area.
6.1.3 Intrinsic Safety Protection

6.1.3.1 I/O modules of Distributed system shall have either built in intrinsic safety or shall use external barriers for intrinsic safety. Safety barriers shall also be used whenever intrinsic safety is specified for contact inputs and solenoid valves. Barriers shall not be required when protection other than intrinsic safety are specified.

6.1.3.2 The system as a whole shall be intrinsically safe based on entity concept. It may be noted that the field instruments are being bought separately and can be of different make and models by different recognised statutory body. These details shall be furnished during detailed engineering. Safety barriers selection shall be carried out based on the entity (safety) parameters which shall be properly matched. Field-bus segment terminator shall be considered for evaluating intrinsic safety of a segment. Any limitation or special requirements for cables to meet the intrinsic safety requirements shall be brought out in the offer.

6.1.3.3 Conventional or smart Instrumentation

a) Whenever intrinsic safety is specified for conventional and smart instrumentation entity parameters of the elements in loop shall be matched with the barrier safety description parameters (i.e. loop design as per entity concept).

b) In case of smart transmitter, the entity parameters of the hand held terminals shall also be considered while selecting proper barriers.

c) Unless otherwise specified all intrinsically safe barriers shall be isolating type only providing isolation between;

i) Input and output (non-hazardous to hazardous side of barriers)

ii) Power supply and input

iii) Power supply and output

The minimum isolation level shall be 250V. In case of I/O modules have built in barriers, I/O modules shall also meet the requirements specified in Clause 6.1.3 of this specification.

d) Unless specifically indicated, only single channel barriers shall be selected. Following shall apply;

i) Dual input barriers shall not be selected

ii) Single input and single output barriers shall be selected.
iii) Single input dual output shall be selected when specifically indicated.

6.1.3.4 Field-bus instrumentation
   a) Whenever intrinsically safe field-bus system is specified with Entity concept, safety parameters of
      various items in the segment shall be matched with the selected barrier.
   b) Whenever FISCO system is specified, all components in the segment is FISCO complied, segment
      power supply selected shall also meet FISCO compliance. Segment design shall also meet FISCO
      requirements.
   c) Whenever non-incendive is specified, all components in the segment shall be FINICO complied
      including segment power supply.

6.1.4 All intrinsically safe barriers shall be of the isolating type only, shunt diode type of safety barriers
shall not be used. Only single channel type of barriers shall be used.

6.2 Power supplies and distribution

6.2.1 System Power Supply

6.2.1.1 Unless specified otherwise, the system shall operate on uninterrupted power supply (UPS). However
      the system shall be capable of operating satisfactorily at the following power supply specifications:

      Voltage : 220 V AC ±10%
      Frequency : 50 Hz ±3 Hz
      Harmonic contents : Less than 5%
      Power interruption : 10 millisecond

      Various main load centres of distributed control system may be sequentially started whenever
      the starting current are high. The requirement of sequential starting shall be specified in job
      specification. The sequential starting circuit shall be designed using hardware timers and contactors of
      adequate rating.

6.2.1.2 The system shall be supplied with dual DCS feeders each capable of handling 100% of the total power
      supply load requirements. The system shall be engineered such that;

      a) The redundant systems / sub-systems shall be powered such that main and redundant
         components are powered from separate UPS feeders.
      b) The non-redundant components / items shall be powered from either of the
         feeders, unless otherwise specified in the job specification.
      c) In case of failure of one feeders, redundant feeder shall supply the total load.
6.2.1.3 Each power feeder shall be monitored for its voltage and current in DCS, the transducers required for the measurement shall be located in power supply distribution cabinet/cabinets.

In addition to above, following indication / alarms shall also be provided for each feeder;

a) Voltmeter, ammeter and power-on-lamp on the cabinet front of respective power supply distribution cabinet.

b) Power failure Alarm contacts for such feeder for DCS monitoring.

c) One common power failure alarm contact for alarm on hardwired console.

6.2.2 DC Power Supply

6.2.2.1 DC supply shall be generally used for ESD devices and shall be 24V DC as specified in job specifications. In general, DC supply shall have the following specifications;

Voltage : 24V ±10%

Harmonic Contacts : ...

6.2.2.2 Each DC power supply feeder shall be monitored for its voltage. The voltage transducer shall be installed in the DC supply distribution cabinet.

6.2.2.3 In addition to above, following indications and alarms shall also be provided for each DC supply feeder;

a) Voltmeter installed on the respective DC power supply distribution cabinet.

b) Power failure alarm contacts for each feeder for DCS monitoring.

c) One common power failure contact for alarm as hardwired console.

6.2.3 Non-UPS Power Supply

6.2.3.1 Non-UPS power supply shall be generally used for panel / cabinet / console lighting, power sockets. The voltage shall be 240V 50Hz power supply. In general, 240V 50Hz Non-UPS power supply shall follow the following specifications;

Voltage : 240V ± 10%

Frequency : 50Hz ± 3%

6.2.3 All cubicles lighting shall be on 240 V, 50 Hz normal power supply.
6.2.4 Power supply shall be made available at one point. Further power distribution network shall be designed such that a single power fault in any instrument branch system shall not cause a trip of the entire system. Each consumer shall be provided with a separate switch and fuse for isolation and protection of the system.

6.2.5 Each transmitter shall preferably be powered with individual power supply. However when several transmitters are powered by a common DC source, each power supply branch shall have a separate switch and fuse. The distribution network shall be designed in such a way that overload in any branch shall not trip the main power supply. Enough redundant power supplies/battery banks shall be provided which shall take over automatically in case of main common power source failure. All power supplies shall have one to one redundancy and shall be sized for full load.

6.3 Equipment assembly

6.3.1 General

6.3.1.1 All system equipment like instruments, electronic modules, power supplies, barriers, relays etc shall be installed in either of the following enclosures / cubicles as specified in purchaser's job specifications. The layout of these enclosures shall be prepared considering proper accessibility and maintainability;

a) Control Panels

All indicating types of dedicated instruments like single loop controllers, indicators, recorders, alarm annunciators, manual loading station manual switches etc shall be installed on control panel when control panel is the operator interface or when specifically indicated in the job specifications.

b) Hardwired Console

All indicating type of dedicated instruments like single loop controllers, indicators, recorders, alarm annunciators manual switches shall be installed on hardwired console when hardwired console is the operator interface or whenever specifically indicated in the job specifications.

Hardwired consoles form the part of main operator console and shall have same design, dimensions, colour, and shape as operator consoles.

c) System cabinets

All system hardware (excluding consoles) shall be installed in system cabinets. This shall include system racks, system modules, communication modules, power supply modules etc.

System cabinets shall be pre-standing type and shall be freely accessible from front and / or back as required. Following system cabinets shall be required, in general;
i) Power distribution cabinet (for AC and DC distribution).

ii) Safety barrier mounting cabinet (when field instrument is intrinsically safe).

iii) Controller and data acquisition sub-system cabinet.

iv) Temperature converter trip amplifier and other auxiliary card mounting cabinet.

v) Shutdown system cabinets (PLC processor and I/O cabinets)

vi) SER Cabinet

vii) Marshalling cabinets

Free issue items mounting cabinet (for mounting items which are free issued to vendor)

6.3.1.2 In general, control panels and hardwired consoles supplement the operator consoles for plant operation. Those instruments which provide direct operating interface to the plant operator are installed on these enclosures / cubicles.

In contrast, system cabinets generally house back and items / equipments / instruments which are not required by the plant operator for direct operation.

6.3.1.3 Mechanical Design

6.3.1.3.1 As far as possible, panels / cabinets / consoles shall be manufactured using standard modular design and standard equipment. Vendor may follow their standard manufacturing procedures, however following points must be ensured:

a) All nuts, bolts, screws, washers (lock or flat) and hinges shall be of stainless steel. All fastening links shall also be of stainless steel.

b) Document pocket / wallet shall be provided on the inner side of front and rear doors of each cabinet and on the inner side of the door of each panel. Similar arrangement shall also be made on the inner side of doors of console.

6.3.1.3.2 Control Panels

a) Control panels shall have self-supporting free standing cubical construction with back doors made up of sectional steel panels. Two doors shall be provided for each panel, as standard.

b) Each panel section shall have the following dimensional details;

   Height : 2000mm

   Width : 1200mm
Depth: 1000mm

Panel shall be rigidly mounted on 100mm high channel base.

c) The panel shall be fabricated using angle iron frame section of minimum 50mm x 50mm x 4.0mm size. The control panel front shall be fabricated preferable from 3.0mm cold rolled carbon steel sheet.

d) Unless otherwise specified the panel shall be straight face type. Desk type panel shall be supplied where specified. Case shall be taken to ensure that the face of the panel is truly float and smooth.

e) Panel painting procedure shall include sand blasting, grinding, chemical cleaning, surface finishing by suitable filler and two coats of high grade lacquer with wet sand blasting between coats. Two coats of paint in the panel colour shall be provided. Final coat shall be given after assembly at site of non-glossy high satin finish when specified in the job specifications. Colour of the panels shall be as per job specifications.

f) Normal mounting heights of instruments (centre lines of instruments to floor) on panel shall conform to the following, with minor adjustments depending upon instruments selected.

<table>
<thead>
<tr>
<th></th>
<th>Miniature and sub-miniature instruments. (3 rows)</th>
<th>Bottom Row Middle Row Top Row</th>
<th>1100 mm 1350 mm 1600 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Annunciators</td>
<td></td>
<td>1950 mm</td>
</tr>
<tr>
<td>3</td>
<td>Electrical push buttons</td>
<td></td>
<td>700 mm</td>
</tr>
</tbody>
</table>

d) Door locking arrangement

All doors of cabinets / panels / consoles shall have flush mounted handles with key operated mechanical door locking arrangement. The locking arrangement shall be interchangeable and shall have common key for locking / unlocking all locks (master keying arrangement).

e) Internal lighting arrangement

Internal illumination shall be provided for all panels / cabinets / consoles to ensure proper illumination level of 250 lux for performing maintenance activities.

Fluorescent lamps shall be provided in each cabinet / console / panel which shall be activated individually by door operated magnetic switches. The lamps shall activate when door is opened and deactivate when the door is closed. The magnetic switches selected shall have undergone life cycle cyclic test of at lest 10,00000 operations. A manual over-ride switch shall be provided inside.
the panel / cabinet / console which shall keep the lamp deactivated even when the door is open. Panels / cabinets / consoles housing memories, which are likely to be effected by fluorescent light, shall have incandescent lamps.

The cabinet / panel / console lighting shall operate on 240V AC emergency power supply.

f) Utility Sockets

Each cabinet / panel / console shall have at least one number each of 240V AC (emergency power) and 220V AC, (UPS) power socket. The sockets shall be rated for 10A as a minimum.

g) Ventilation

In order to effectively remove dissipated heat from the cabinets / panels / consoles, ventilation fans along with vent louvers backed by wire fly screen shall be provided as required. Ventilation fans shall be provided in all cabinets / panels / consoles where the temperature rise with all doors closed and all internal and external loads energised shall exceed 10°c above the ambient temperature. A temperature element (resistance temperature detector) shall be provided in each cubicle for temperature measurement. Ventilation fans shall be provided in dual configuration, as a minimum.

Each fan shall have a separate dedicated assembly and shall be replaceable on-line without shutting down any equipment / panel / cabinet / console in part or in complete.

Ventilation fan assembly shall operate at 240V AC emergency power supply. Each fan shall have its own dedicated circuit breaker.

Each ventilation fan shall be fitted with a protection type finger guard. Whenever, the number of panels / cabinets / consoles are compacted (supplied in mechanical joined conditions), each panel / cabinet / console shall be provided with separate ventilation fan assembly.

The maximum noise level with all fans operating and cubicle doors open shall not exceed 85dBA. Following signals and alarms shall be provided for each panel, cabinet and console separately;

i) Fan failure alarm for each cubicle in DCS.

ii) Temperature indication of each cabinet or compacted combination, as applicable in DCS.

iii) A common alarm each for high temperature and fan-failure on hardwired console.

h) Earthing

Each cubical (panel / cabinet / console) shall be provided with earth bus bars of at least 15 x 5 square mm cross-section for the following;
i) Electrical earthing (non-isolated earth) where all metal components like all cabinet panels, doors etc shall be connected.

ii) System earthing (isolated earth) where cable shielding of all cables shall be earthed. System earth bus bar shall be isolated from electrical earth and also from metallic doors, panels etc.

iii) DC earth (isolated earth) where cable shielding of all 110V DC shall be earthed. DC earth shall be isolated from electrical earth, system earth and also from metallic doors, panels etc.

i) Lifting lugs

All control panels and system cabinets shall be provided with removable lifting lugs to permit lifting of panels / cabinets. The panel structure / frame shall be designed to permit panel / cabinet lifting without deformation. The normal working load of the lifting lugs shall be more than 1.5 time the panel / cabinet load. The eye bolts shall be certified for their normal working load. Panels / cabinets shall also be supplied with plugs which can be fitted after the lifting lugs are removed after their placement.

j) Name Plates

All panels / consoles / cabinets shall have name plates fixed on the front, back and inside with following details;
Front and Back : Tag number and description
Inside : Manufacturer’s name, purchase order number and year of manufacture, port number of manufacture.

All other details shall be as per clause 5.1.22 of this specification.

6.3.1.3.3 System cabinets

a) All the cabinets shall be free standing, enclosed type and shall be designed for bottom entry for cable connection. Cabinets structure shall be sound and rigid.

b) Cabinets shall be equipped with front and rear access doors. Doors shall be equipped with lockable handles and concealed hinges with pull pins for each door removal.

c) Each cabinet shall have the following dimensional details;

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>2000mm</td>
</tr>
<tr>
<td>Width</td>
<td>600mm / 1200mm</td>
</tr>
<tr>
<td>Depth</td>
<td>800mm</td>
</tr>
</tbody>
</table>
Cabinets shall be rigidly mounted on 100mm high channel base. Construction shall be modular preferably to accommodate 19" standard electrical racks. All racks shall be of same height. Maximum swing out for doors and drawers shall be limited to 600 mm.

d) Cabinets shall be fabricated from cold rolled steel sheet of minimum 2 mm thickness suitably reinforced to prevent warping and buckling. Doors shall be fabricated from cold rolled steel sheet of minimum 1.6 mm thickness. Cabinets shall be thoroughly deburred and all sharp edges shall be grounded smooth after fabrication.

e) Equipment, within the cabinet, shall be laid out in an accessible and logically segregated manner. All metal parts of the cabinet including doors shall be electrically continuous and shall be provided with a common grounding lug.

f) Cabinet painting procedure shall include sand blasting, grinding, chemical clearing, surface finish by suitable filler and two coats of high grade lacquer with wet sand blasting between the coats. Two coats of paint shall be provided. Colour of the cabinet shall be as per job specifications.

6.3.1.3.4 Electrical Wiring

All the cabinets, consoles and panels shall be completely wired and/or tubed, as required. Interconnections shall preferably be done with the help of pre-tracked cables. Vebdir may follow their standard wiring practices, however the requirements specified herein must be complied.

6.3.1.4.1 Terminals and Terminal Blocks

a) All terminal / terminal blocks shall be DIN Rail mounted type and shall be easily removable. The size of the terminal blocks / terminals of different types shall be consistent and identical.

b) All terminal blocks shall be mounted on suitable anodised metallic or plastic stand-off.

c) Terminal strips shall be arranged group-wise for incoming and outgoing cables separately. Terminal blocks for intrinsically safe wiring shall be separate. 20% spare terminals shall be provided, as a minimum, preferably in each terminal strip.

d) Terminal housing shall be strictly sized with considerations for accessibility and maintenance. Minimum distance required between various components are listed below. These distances are clear distances, and are excluding the width of the raceways or any other component / item mentioned herein. Following clearances should be considered;

   i) Distance between terminal strip and side of the cabinet parallel to the strip, up to 50 terminals, shall be minimum 50mm.

   ii) Distance between terminal strip and, top and bottom of the cabinet shall be minimum 75mm.
iii) Distance between two adjacent terminal strips shall be minimum 100mm.

iv) Additional distance for each additional 25 terminals shall be minimum 25mm.

v) Distance between cable gland plate and the bottom of the strip shall be minimum 300mm.

6.3.1.4.2 Terminals

a) Terminals shall be non-hygroscopic type made up of unbreakable fire-retardant, safe extinguishable, halogen free polyamide compound of VO grade of 960°C. These shall be manufactured as per IEC-60947-7-1.

b) Terminals shall be suitable for wires up to 2.5 sq. mm base solid or standard conductor in general. For power cables, higher size terminals shall be used.

c) The metal parts of terminals shall be of high quality (pure electrolytic) copper and shall be tin or nickel plated (of thickness up to 15 micron). The contact terminal resistance shall be of the order of 0.3 multi ohm.

d) The spring material for all terminals shall be chrome nickel spring steel of high tensile strength and of excellent corrosion resistance.

e) Voltage withstand capacity of the terminals shall be up to 4KV for 60 seconds as per IEC/EN-60664-1.

f) Field side terminal blocks in marshalling cabinet shall be cage clamp interruptable (i.e. disconnect) terminals providing necessary polarity distribution, protection, test point and earthing.

6.3.1.4.3 Wiring Requirements

a) All wiring shall conform to SPI RP 550 Part-I, Sections 7 and 12. Different signal level cables shall be routed under false flooring with separation distances as recommended by API RP 550 Section 7.

b) All wiring inside racks, cabinets, and back of the panels shall be housed in covered, non-flammable plastic raceways arranged to permit easy assembly to various instruments for maintenance, adjustments, repair and removal.

c) All wiring in the raceways shall be properly clamped. All incoming cable shall be terminated by vendor at marshalling rack with cable glanding including supply of cable glands. Total wiring cross-sectional area shall not exceed 50% of the raceway cross sectional area.
d) Separate wiring raceways shall be used for power supply wiring, DC and low level signal wiring, and intrinsically safe wiring. Parallel runs of AC and DC wiring closer than 300mm shall be avoided.

e) Vendor can alternately offer prefabricated cables for interconnection between different cabinets and panels.

f) Wire termination shall be done using self-insulating crimping lugs. More than two wires shall not be terminated on one side of single terminal. The use of shorting links for looping shall be avoided.

g) No splicing is allowed in between wire / cable straight run.

6.3.1.3.5 Hardwired console

a) Hardwired console shall be non-graphic self supporting, free standing cubicle with back doors and shall be designed for better cable entry for connections. Console structure shall be sound and rigid.

b) The design and dimensions of hardwired console shall strictly match with the operator consoles. For designing hardwired console, following points must be ensured;

- No instrument or switch shall be installed on the horizontal portion of console.
- Horizontal portion of console shall be spill proof, as well as scratch proof. Materials other than metallics can also be accepted for horizontal portion provided this can provide rigid, hard, flat and smooth surface. This shall require the purchaser's approval prior to deciding the material.
- In order to reduce number of hardwired consoles, vendor may utilize back-lighted switches and miniature instrumentation and annunciator windows.

c) Whenever the operator consoles are specified with table top design instead of console type of design, the hardwired console shall be identical and symmetrical to the operator console design.

d) Panels/hard wired console shall be fabricated preferably from 3 mm thick cold rolled steel sheet. Angle iron frame shall use a minimum section of 50 x 50 x 4 mm angle.

e) Cabinet paint procedure shall include sand blasting, grinding, chemical cleaning, surface finish by suitable filler and two coats of high quality laquer with wet sand blasting between two coats. Two coats of paint shall be provided. Colour of hardwired console shall be as specified in job specification.

6.4 Earthing

6.4.1 All system equipments such as panels, marshalling cabinets, system cabinets and other powered equipments shall be provided with following type grounding system;
a) Protective Earth / Electrical Earth

b) System earth / signal earth

c) Safety earth / ZB earth (when required)

d) SPD Earth

Both system earth and safety earth shall be totally separate from protective earth.

6.4.2 Protective earth / Electrical earth

a) Earth metallic enclosure / cabinet / panel / console etc shall be provided with electrical earth lug, as a minimum. Door hinges, flexible conduits or self-detachable connectors shall not be considered path for earth connectivity/earth return paths. Separate earth lug or permanent connectivity shall be considered.

b) Unless recommended otherwise by vendor, all earthing lugs of metallic equipments indicated in Clause 6.4.2(a) above shall be connected individually to electrical protective earthing system bus-bar / earthing station using a maximum of 10sq mm solid copper conductor PVC installed wires.

c) Where multiple cabinets are multiplexed together, earth looping with permanent shorting link cables shall be acceptable. Two earthing connection wires as indicated in Clause No.6.4.2(b) above shall be used for connecting multiplexed cabinets to protective earth station / bus-bar.

6.4.3 System Earth

a) System earth shall be totally noise free dedicated earthing system and shall be fully isolated from electrical protective earth. This earth must be very high integrity system and shall be used to ground zero volt references and signal cable grounds.

b) System earth shall be less than one (1) ohm grounding system with its own dedicated earthing pits. These earth pits shall be away from any heavy noise plant equipment. Outside the control room building is the most appropriate location.

c) The earth pit design shall be as per IS-3043 code of practice for earthing. A minimum of four (4) number of earth pits shall be provided for grounding system integrity. In case number of pits required to meet 1 ohm resistance are more than (2), the number of earth pits shall be two times the actual number of pits required to meet resistance criteria. All
these pits shall be security connected with each other to form a one homogeneous system earth grid.

d) Each marshalling / system cabinet / panels etc shall be provided with system earth bus-bar which shall be insulated from the metallic body frame. This bus-bar shall be used to earth also signal zero volt references and signal cable screens. Terminals used for termination of spare conductor pairs / cores of multi-pair signal / control cables shall be connected to system earth bus-bar. Shorting links shall be used for spare terminal looping.

e) System bus-bars in the multiplexed cabinets can be joined together by permanent shorting links. System bus-bars of other cabinets can also be connected together provided they are permanently joined using 35 sq mm stranded copper conductor cable in a looped both ends except for the following exceptions;

6.4.4 Safety earth / Zener barrier earth

a) Whenever Zener barriers are selected or used to meet intrinsically safe requirements, the earthing terminal of the zener barriers shall be connected to a separate earth bus bar.

b) This earth shall meet all the requirements specified in Clause 6.4.3 of this specification.

c) Safety earth bus bar shall be directly connected to earth pits using dual insulated cable. Cable conductor size shall be minimum 95 sq. mm (copper).

6.4.5 SPD Earth

a) SPD earthing terminals are connected to separate earthing bus bar in the cabinets.

b) This earth shall meet all the requirements specified in Clause 6.4.3 and 6.4.4(c) of this specification.
PART - II

TESTING, INSTALLATION, COMMISSIONING
AND ACCEPTANCE OF
DISTRIBUTED CONTROL SYSTEM
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1.0 SCOPE

1.1 This specification defines the basic guidelines to Distributed Control System vendor for factory testing and acceptance, installation, commissioning and field acceptance of the fully integrated system.

1.2 These guidelines shall also be applicable to all sub-systems and hardware bought by DCS vendor.

1.3 On the basis of this specification, vendor shall submit detailed testing and acceptance procedures specifically applicable for their system. The procedure shall include both hardware as well as software testing and acceptance methodology covering following details:

a) Hardware Testing;
   The procedure shall include;
   i) Test name
   ii) Purpose of Test
   iii) Test equipment
   iv) Test set-up (Block diagram)
   v) Input definition
   vi) Test procedure
   vii) Results expected
   viii) Acceptance criteria.

b) Software Testing;
   The procedure shall include;
   i) Test name
   ii) Purpose of Test
   iii) Test equipment
   iv) Test set-up
   v) Sequence of Execution
   vi) Results expected
   vii) Acceptance criteria

The procedure shall not omit any column as indicated above in the procedure submitted. Indicate 'NA' whenever any column is not applicable. Additional requirement, if any may be include, as applicable.

1.4 The testing and acceptance of the system shall be carried out on the approved testing procedures and criterion based on this specification and vendor’s standard testing requirements and procedures.

2.0 FACTORY TESTING AND ACCEPTANCE

2.1 General
2.1.1 Vendor shall test and demonstrate the functional integrity of the system hardware and software. No material or equipment shall be transported until all required tests are successfully completed and certified “Ready for Shipment” by the owner/consultant.

2.1.2 The purchaser reserves the right to be involved and satisfy himself at each and every stage of inspection. The purchaser shall be free to request any specific test on any equipment considered necessary by him although not listed in this specification, as a part of approval of factory testing procedure. The cost of performing all tests shall be borne by the vendor.

2.1.3 Vendor to note that acceptance of any equipment or the exemption of inspection or testing shall in no way absolve the vendor of the responsibility for delivering the equipment meeting all the requirements specified in Material Requisition.

2.1.4 It shall be vendor’s responsibility to modify and/or replace any hardware and modify the software if the specified functions are not completely achieved satisfactorily during testing and factory acceptance.

2.1.5 Failure of components/ modules/ sub-systems during Testing

2.1.5.1 Vendor shall not replace any system component/module/sub-system unless it is failed. A log of all failed components/modules in a sub-system shall be maintained which shall give description of the failed component/module, effect of failure on the sub-system, cause of failure and number of hours of operation before it failed.

2.1.5.2 If malfunction of a component/module in a sub-system repeat, the test shall terminate and vendor shall replace the faulty component/module. Thereafter the test shall commence all over again. If even after this replacement, the sub-system fails to meet the requirements, vendor shall replace the full sub-system to the one meeting the requirements and the system shall be tested all over again.

2.1.5.3 If a sub-system fails during the test and is not repaired and made operational within four hours of active repair time after the failure, the test shall be suspended and restarted all over again only after the vendor has replaced the device in the acceptable operation.

2.2 The factory testing and acceptance shall be carried out in two phases i.e. Phase I and Phase II. The schedule for the testing shall be submitted by the vendor for both Phase I and Phase II separately. The minimum requirements for testing during these two phases are as follows:

2.2.1 Phase-I

2.2.1.1 Vendor shall perform tests at his works to ensure that all components function in accordance with their respective specifications. A test report shall be submitted to the owner/consultant for review within one week of completion of testing giving details. Phase II testing (witness inspection) shall start only after.

2.2.1.2 All sub-systems shall undergo a minimum of 30 days (720 hours) burn-in period. The system shall be offered for factory acceptance only after it has completed the specified burn-in period. The requirements shall be as follows;
a) The burn-in time shall start after the sub-system is fully assembled and is powered up. It may include any such time for which the system has been kept powered on even for system generation and Phase I testing.

b) Burn-in period log report shall be maintained by the vendor clearly recording sub-system (Tag No. / Identification No.), date and time of power-on, date and time of power-off, failed component (if any) with identification, communicative power-on time and sign-off. In case power to the sub-system is switched off because of any reason, the same shall be recorded in this log report.

c) Vendor shall submit burn-in period log report as part of Phase I test report for purchaser's review.

2.2.1.3 All the test results shall be recorded in the test log report. The test logbook shall contain the following information about the tests:

a) Date/time
b) Assembly / loop tag number
c) Test input
d) Test results and sign off with personnel name
e) Action required (if deficiency is detected)
f) Action taken, date of completion and sign off
g) Special test methods (including special equipment requirement, bypasses used etc.)

2.2.1.4 Test details

Following tests shall be performed by the vendor and report shall be forwarded to the owner/consultant.

2.2.1.4.1 Quality control test

a) Quality control tests shall be carried out to assure quality of all components and modules in accordance with vendor’s quality control and assurance procedures. QA / QC test methodology shall be in accordance with relevant international standards and practices. Vendor shall forward the details of these procedures for purchaser’s review.

b) The sampling procedures for all purchased components or components manufactured by the vendor shall be in accordance with the vendor standard quality assurance / quality control procedures.

c) All assemblies shall be aligned and adjusted before conducting tests. All tests shall be carried out as per manufacture's published / established testing methods and shall be recorded in a test logbook. The test logbook shall be duly signed by the QA / QC manager.

2.2.1.4.2 System power-up tests
All sub-systems shall undergo complete functional testing as part of Phase I power-up testing. Testing shall include, but not limited to, the following;

a) System hardware functional testing including redundancy, wherever applicable, as per vendor standard testing procedures.

b) System software testing as per vendor standard testing procedure including builder functionality.

c) System performance on power supply variations as per vendor standard procedures.

d) Application, Software testing;

Complete application programme generated by the vendor specific to the job shall be tested by simulating inputs. This shall include the following, as a minimum;

- Database verification including loop configuration as per approved functional schematics.
- Display verification including dynamic graphics and hierarchical displays.
- Trending, real time and historical, functionality and assignment.
- Logging and report generation
- Serial port assignment and its proving
- Security functionalities, as applicable e.g. password functionalities, fire-wall protection
- Testing of third party equipments (if applicable)
- Verification of logic diagrams
- Alarm management verification
- Any other software verification necessary for the offered system, as per vendor standard.

e) System Diagnostic verification

All the test results shall be recorded as per Clause 2.2.1.3 of this specification.

2.2.2 Phase II (Witness Inspection)

2.2.2.1 During Phase II testing, all the hardware and software shall be systematically, fully and functionally tested in the presence of purchaser representative.

All the sub-systems shall be interconnected to simulate, the totally integrated system as close as possible. Vendor purchased items (third party equipment) e.g. programmable logic controller, sequence of event recorder, alarm information management system etc shall also be integrated with the system. Free issue item, if any supplied by purchaser to the vendor for integrated factory acceptance test, shall also be integrated with the system. Barrier cabinets shall be used as the connecting points for the test inputs and outputs.
2.2.2.2 The duration of Phase II testing shall be communicated by the vendor along with day wise testing schedule to the purchaser. System shall be shipped to site only after the successful completion of this testing and the system is certified 'ready for shipment' by purchaser.

2.2.2.3 Data review:

Purchaser shall review the following documents before starting the witness Inspection (Phase II);

a) The latest document revisions, based on which vendor has generated the system, to the current data. Any revision or changes required shall be informed to the vendor before starting the witness inspection.

b) Test reports of all bought-out items by their respective manufacturers.

c) The test report/log book forwarded by vendor after Phase-I testing. Owner / consultant has right to witness any test performed in Phase I, if found necessary.

2.2.2.4 Testing record

a) During testing of Phase II, each test carried out shall be recorded. Any deficiency or problem observed during testing shall be clearly recorded and corrected thereafter.

b) Vendor shall prepare a punch list report listing out all the action points. All punch list actions must be completed before system dispatch.

c) Any change in the data or configuration etc informed to the vendor during testing by purchaser shall be recorded and modifications required shall be carried out by the vendor.

2.2.2.5 Visual and mechanical testing.

Visual and mechanical testing shall be carried out in principle to assure correct, proper, good and neat workmanship by the vendor. This testing shall include the following, as a minimum;

i) Dimensional verification

ii) Sheet thickness

iii) Layout verification as per approved GA drawings

iv) Quality of painting (outer and inner)

v) Nameplates, identifiers and tag plates

vi) Adherence to ferruling philosophy.

vii) Dressing of wires / prefabricated cables and clearances

viii) Locks and handles

2.2.2.6 Verification of Bill of Material (BOM)

Hardware and software including bought-out items shall be available for verification with the bill of material (BOM) document submitted by the vendor during engineering. Vendor must obtain
purchaser's prior approval if any sub-system or bought-out equipment / item can't be made available
during Phase II testing i.e. witness inspection. The verification of BOM shall include the following;

a) Hardware verification

The verification shall include verification of all hardware including mandatory spares as per the
model numbers and quantities indicated in bill of material document. Items which can't be
identified with model numbers, shall be verified with manufacturer's serial numbers. In all such
cases, vendor must ensure that the serial number has been indicated against all such items in the
BOM document.

b) Software verification

The verification shall include verification of licenses and their numbers for all softwares as listed in
bill of material document. All licenses shall be in the client's name. Number of copies of as built
application programmes shall be verified at the time of site acceptance test and not during factory
acceptance test.

All system hardware including network interfaces and all software including operating system, console
software, network software, complete application software etc. shall be installed and tested as part of
function testing.

2.2.2.7 Functional testing

All system hardware including network interfaces and all software including operating system, console
software, network software, complete application software etc. shall be installed and tested as part of
function testing.

Functional testing shall include the simulation of inputs and outputs to verify proper system response
for both analog and discrete signals. Unless otherwise specified, at least 20% of I/O's shall be simulated
in controller and data acquisition sub-system while all I/O's shall be simulated and corresponding logics
shall be verified in case of Programmable logic controllers. The I/O sampling shall be at random and
shall be selected by the purchaser during testing. The testing, as a minimum, shall include the
following:-

a) Complete system configuration loading.

b) Controller and Data acquisition Sub-system

Demonstration of all controller functionalities verification and data acquisition sub-system
functions from local as well as from central level including;

- Changing control algorithms
- Changing control mode and controller action
- Changing alarm limits
- Controller tuning using tuning trend.
Controller tuning using auto-tuning package and change in tuning package and change in tuning parameters either automatically or manually.
- Output status on controller failure.
- Setting of macro-cycle time for fieldbus segment.

c) Scan time verification of scan time values for controllers and data acquisition sub-system and PLC testing shall be carried out by simulating the inputs as follows;

i) Open or close the contact input as per logic execution requirements.

ii) Step input or slow ramp input (typical frequency of 4 cycles / second) with amplitude corresponding to 16mA (4mA to 20mA or vice versa) for all conventional analog and smart (HART) inputs from a signal generated.

The processor cycle time setting and the processor loading shall not exceed the specified limits while verifying scan time.

Checking of scan time values for controllers and data acquisition sub-system and PLC;
The inputs to the system shall be;

- Step input i.e. 0 or 1 for all contact inputs.
- Step input or ramp input for all analog inputs

The processor cycle time setting and the processor loading shall not exceed the specified limits while verifying scan time.

Control cycle time shall be measured by simulating a segment with transmitters and positioners in the worst case fieldbus segment (w.r.t number of transmitters and positioners) and scheduled activities.

d) Checking of correct change-over of the back-up units in case of main unit failure. This shall include the following:-

i) Uninterrupted controller operation shall be verified even during and after switchover of back-up device. The failed controller Database, point records, inputs and outputs of the failed main controller shall be transferred to the back up controller without any interruption. The same shall be repeated for transfer back from back up controller to the main controller. Maximum transfer time shall not exceed the specified value. The test shall be repeated for controller all redundant devices including input /output modules.

ii) Uninterrupted data transfer from main communication network and communication interfaces to the redundant ones shall be checked. The transfer back from back-up device or back-up communication network to main network or interface shall not be automatic (automatic transfer from back-up device / network to main device / network shall also be
acceptable in case the changeover procedure is flawless and smooth). This test shall be
repeated for all interface units in the system including foreign device interfaces.

iii) Uninterrupted operation of system shall be checked on failure and resumption of any of the
power supplies where redundant power supplies are provided.

iv) Uninterrupted operation of the system incase of redundant H1 module, power supply
conditioners and LAS functionality.

e) Checking of controller loading

Controller loading shall be verified as displayed by the system by simulating as many as inputs to
simulate worst case data transfer condition.

f) Simulation of fieldbus segment

At least one fieldbus segment of each type (e.g. foundation fieldbus, profibus etc) shall be
simulated as applicable. The segment shall include at least one device of each make and model
number being used in the project (purchaser shall identify and provide the device to vendor for
segment simulation). Following minimum tests shall be carried out;

i) Inter operability test to ensure correct data transfer between devices of different makes and
host (i.e. DCS).

ii) Control cycle time verification as per specifications.

iii) Control loop functionality when control algorithm is configured in DCS and in a field
device i.e. positioner and in transmitter.

iv) Verification of functionality of control input data transfer along with fieldbus converter by
simulating inputs.

g) Functional verification of cursor movement devices

Verification of correct functioning of all keyboards, mouse, touch screens, light pen etc shall be
carried which shall include;

i) Smooth functioning of all devices.

ii) Functional commands verification

iii) Dual function key configuration.

The devices shall include those attached to operator console, engineering console, PLC console,
personal computers, other sub-systems / accessories.

h) Verification of loop configuration

Data base and the configuration of all the loops shall be verified for their correctness with respect
to range, limits, engineering units, alarm set points, software configuration, output status of
controller / control block failure etc with respect to latest revisions of instrument details and functional schematics / P&ID's supplied by purchaser.

i) Verification of Displays

All types of displays, process as well as system, configured on operator console, engineering console and PLC console shall be verified with respect to correct display configuration, colour scheme, colour modifiers, engineering units, windowing feature, alarms, flags, restricted operation etc.

j) Verification of functionality of accessories

All the accessories like printers and hard copiers shall be verified for their proper operation by printing either test data or actual data.

k) System Diagnostics

System diagnostics shall be thoroughly checked for all sub-systems on local level as well as on operator/engineering console. These shall include diagnostics of failure of main as well as redundant items such as a sub-system, sub-system module, HI module, LAS functionality, power supply, interface unit, network and network module, consoles, third party device interfaced with DCS, printers, hard copier, server failures, key-board / cursor movement devices, disc and disc drives, field-bus devices, field-bus segment, network devices etc. and other detailed diagnostics and their corresponding displays. Diagnostic alarms for any ventilation fan failure, cabinet temperature high and corrosion monitor shall also be verified.

l) Verification of Application programme

Following application programming shall also be verified thoroughly in addition to the complete loop operation by simulation;

i) Verification of trending and trend displays.

ii) Verification of historisation functionalities

iii) Verification of alarm management

iv) Verification of data retrieval functionalities.

v) Verification of all dynamic graphics.

vi) Verification of interchangeability between various video screens of a console.

vii) Synchronisation of system clocks.

viii) Verification of various log formats and log reports including MIS reports as applicable.

ix) Complete (100%) verification of interlock and shutdown logic by simulating inputs and verifying outputs preferably using simulator, other related functions like forcing, first out shall also be verified.
x) Verification of third party device (like PLC, analyser system, computers, MMS, F&G systems etc) interfaces for complete data transfer between device and DCS and vice versa. Where third party devices are not supplied by vendor (and cannot be provided by purchaser for conducting factory testing), the complete address mapping shall be verified and the link shall be proved using third party device simulation.

xii) Verification of data and reports related to instrument asset management system.

m) Verification of other specific requirements when specified like;

i) Large screen functionality and display solution shall be verified along with large screen controller. Where large screen is not available during factory acceptance test, vendor may utilize a PC in place of display unit for application verification.

ii) Verification of all functionalities of alarm information and management system including report generation.

iii) Verification of functionalities of unit history node and its verification. The verification shall include configuration verification, sample rate versus storage time verification (by extrapolated method for extended time period), throughput, report formats and report generation.

iv) OPC node verification with respect to its configuration, data structure and throughput.

v) Sequence of Event Recorder functionalities verification by verifying identification of events with the specified resolution. The input shall be generated using pulse generator of suitable frequency.

vi) Functionalities of other items when specified shall also be verified.

n) Verification of hardwired console and its functionality. All functions shall be 100% verified such as operation of hardwired instruments, hardwired annunciator, switches, ramps, pushbuttons, instruments like controllers, indicators, recorders etc. Hardwired consoles must be present during factory acceptance test and shall be interconnected for functional verification. All hardwired instruments like alarm cards, barriers and relay shall also be verified for their proper operation.

o) Verification of all system builder functions and engineering console functionalities.

p) Verification of fieldbus simulator functionalities when specified and purchased along with the system.

q) Verification of display update rate and call-up time under worst loading conditions. Network performance shall also be verified by verifying display update rate of an analog tag number when all other inputs in the system are under varying conditions.
2.2.2.8 The vendor shall notify the owner/consultant at least three weeks prior to final system testing. In the event that representatives arrive and the system is not ready for testing, the vendor will be liable for back charges for any extra time and expenses incurred.
2.2.2.6.4 Checking of loop configuration for correctness with respect to ranges, limits, alarm points, engineering units etc.

2.2.2.6.5 Checking of all types of VDU displays including process and system displays on operator Engineering and PLC console.

2.2.2.6.6 Checking of correct functioning of key-board operation for operator, Engineering and PLC console.

2.2.2.6.9 Testing of proper functioning of all printers and hard copy units.

2.2.2.6.10 Testing of system features like interchangeability between VDUs of a console, synchronisation of system clocks, selective tuning from Engineering console, key-lock functions etc.

2.2.2.6.11 Checking of various log formats, shut down reports, I/O mapping and other MIS formats printing.

2.2.2.6.12 Checking of shutdown and interlock configuration and proper operation thoroughly.

2.2.2.6.13 Proper system operation at power supply specifications specified in the Material Requisition.

2.2.2.6.14 Checking of proper operation of all interfaces with the system like interface with PLC, computer, analyzer system etc as specified in Material Requisition.

2.2.2.6.15 Checking of bus-degradation while loading the bus from 10% to 100%.

2.2.2.6.16 Simulation of power failure and restarts.

2.2.2.6.17 Checking of all hardwired instrumentation including all alarm cards, alarm annunciator system, switches and other indicating instruments.

3.0 INSTALLATION, TESTING AND COMMISSIONING

3.1 Vendor shall offer the services of the installation team which would install the equipment in the control room, lay the interconnecting cabling inside the control room, check out, test and commission the system.

All technical personnel assigned to the site by the vendor shall be fully conversant with the supplied system and software package, and shall have both hardware and software capability to bring the system on line quickly and efficiently with a minimum of interference with other concurrent construction and commissioning activities.
3.2 Vendor’s responsibility at site shall include all activities necessary to be performed to complete the job as per material Requisition including:

   a) Receipt of hardware/software and checking for completeness of supplies.

   b) Installation of the system including free supply equipment and field cable termination in the system.

   c) Check out of the equipment installation.

   d) Checking of interconnection, hardware & software configuration, overall system functioning etc.

   e) Loop checking.

   f) Liaison with vendor’s home office.

   g) Field tests

   h) Commissioning and on-line debugging of the system.

   i) Performance of final acceptance test.

3.3 The only exclusion from vendor’s responsibility shall include the following:

   a) All civil works in the control room including false flooring, control room lighting and air conditioning ducting.

   b) Laying and identification of field cables.

   c) Field instrument installation and calibration.

3.4 Field Inspection

3.4.1 All equipments shall be inspected thoroughly by vendor after its receipt at site. The tests, as a minimum, shall include:

   (a) Hardware verification as per packing list.

   (b) Visual and mechanical checking.

   (c) Complete System Configuration loading.

   (d) Functioning of all VDUs, keyboards, disc drives, printers, hardcopy units etc.
(e) Checking of correct change-over of redundant devices.

(f) Checking of hardwired instruments.

(g) Any other checking.

3.4.2 The testing defined in para 3.4.1 shall be carried out to ensure functional integrity of all hardware being supplied. Vendor must initiate the remedial action in case unsatisfactory operation of any equipment or item is observed during this testing with an intimation to Engineer-in-charge.

3.4.3 Vendor must document all observations including details of malfunctions observed, if any. Items/equipments requiring total replacement must document reasons for the same.

3.5 Loop Checking

3.5.1 Vendor shall be responsible for loop checking which shall also include checking of the interconnection, at control room end, configuration and ensuring over all system functioning.

3.5.2 Calibration and installation of field instruments, installation of junction boxes, interconnection between instruments and junction boxes, laying of single, multi pair cables upto control room, tagging all field cables, performing continuity/insulation test of cable, core identification of field cables etc. shall not be in the vendor scope. This work shall be carried out by the field contractor.

3.5.3 Vendor’s scope of work, as a part of system installation and loop checking shall include termination of all field cables in control room, checking of interconnection between instrument glanding and equipment, ferruling and tagging of interconnecting cables in control room, ferruling of field cables in control room and performing overall loop performance check.

3.5.4 Loop checking shall be carried out to check the functional performance of all elements comprising the loop and thereby ensuring proper configuration, functioning and interconnection.

For fieldbus devices the loop checking shall include the checking of complete fieldbus segment connectivity with its devices including noise, device configuration, waveform checking. The complete device configuration shall be downloaded to all field devices from DCS prior to the start of loop checking.

3.5.5 Vendor shall co-ordinate with the field contractor for smooth and proper loop checking. Any discrepancy found during checking shall be brought to the notice of Engineer-in-Charge. Complete loop checking shall be performed in the presence of Engineer-in Charge or his authorised repre-
sentative. All readings shall be recorded on a suitable format which shall be handed over to the vendor by the field contractor after completing calibration record of each field device. On the completion of loop checking, remaining information related to loop checking shall be filled by the vendor. Completely filled format duly signed shall be submitted for approval, to Engineer-in Charge.

3.5.6 a) All the components of the loop shall be checked for proper functioning. All field instruments connected to control room shall be loop checked at 0%, 50% & 100% of FS (for both increasing and decreasing signals). The mode of generating signal from the field by field contractor shall be as follows for different instruments types:-

<table>
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<th>Type of Instrument</th>
<th>Mode of Signal Generation</th>
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<tr>
<td>a) Differential pressure/ flow instruments/ DP type level instruments</td>
<td>By applying impulse to the primary by squeeze bulb or regulator at field</td>
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<tr>
<td>b) Pressure instruments</td>
<td>By applying impulse to the instrument using instrument air, regulator &amp; standard gage or using portable hydraulic pump and standard gage.</td>
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<tr>
<td>c) External Displacer</td>
<td>Cage shall be filled with water for different levels and specific gravity correction shall be applied</td>
</tr>
<tr>
<td>d) Other type of tank level instruments</td>
<td>By lifting the float of the level instruments for 0% and 100% of range</td>
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<tr>
<td>e) Temperature loops with thermocouple</td>
<td>Appropriate mV signals shall be fed from thermocouple head</td>
</tr>
<tr>
<td>f) Temperature loops with RTD</td>
<td>Appropriate resistance shall be fed from RTD head</td>
</tr>
<tr>
<td>g) Field switches for Alarm &amp; Shutdown</td>
<td>Abnormality shall be simulated by disconnecting and connecting the wires at field instruments end</td>
</tr>
<tr>
<td>h) Owner supplied items</td>
<td>As per Engineer-in-Charge’s Instructions</td>
</tr>
<tr>
<td>i) Special instruments &amp; any other type of instruments</td>
<td>As per Engineer-in-Charge’s Instructions</td>
</tr>
</tbody>
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b) Receiver alarm cards shall be checked by the vendor for different settings on both increasing and decreasing signals.

c) Shutdown schemes shall be checked for proper functioning, configuration and actuation.

d) Performance of individual loops may be accepted for an overall accuracy of ± 1.0% unless otherwise specified. Where deviation exists, re-calibration of instruments, based on the scope of work, shall be carried out either by field contractor or by vendor.

e) Signal from controllers/shutdown schemes to control valves/shutdown valves shall be checked at the respective valves. The stroke checking including checking of time of operation of control
valves/shutdown valves also forms a part of loop checking. Vendor shall coordinate this activity with field contractor and record the same in the loop checking format.

f) For the loop checking of loops connected to substation, vendor shall be responsible to coordinate with the Electrical Contractor.

g) After loop checking is completed, vendor shall connect back any terminals and connections removed for loop checking.

4.0 SYSTEM ACCEPTANCE

4.1 The owner shall provisionally takeover the system from vendor after System acceptance test. System acceptance test shall be started only after the satisfactory performance of loop checking and verification of all loop checking records by Engineer-in-charge.

4.2 The system acceptance test shall be carried out in the presence of owner's representative and Engineer-in-charge or his authorised representative. The tests carried out in System acceptance test shall be fully recorded and duly signed by all representatives participating in the System Acceptance Testing.

4.3 Vendor shall carry out the following functional tests on the fully integrated system as a part of System acceptance test, as a minimum;

a) Hardware verification as per final Bill-of-material.

b) Visual and mechanical checking for proper workmanship, identification, ferruling, nameplates, etc.

c) System configuration as per approved configuration diagram.

d) Checking of correct functioning of all keyboards and dual function keys.

e) Checking of proper operation of hardcopy unit and all printers including printing of Alarms and Events on the Alarm & Event (A&E) printer.

f) Demonstration of all system diagnostics.

g) Checking of correct changeover of redundant devices.

h) Checking of redundancy for LAS functionality for fieldbus segments.

i) Checking of communication between DCS, PLC and other foreign devices.

j) Checking of proper functioning of all disc drives, historical trend-points, alarm summary and alarm history.
k) Verification of proper functioning of assignable trend recorder

l) Printing of Configuration and Configuration changes on C&M printer.

m) Proper information transfer on the information network by verifying system displays and printouts.

5.0 FINAL ACCEPTANCE TEST

5.1 The owner will take over the system from the vendor after the final acceptance test, which is defined as successful uninterrupted operation of the integrated system for three weeks for all units of the plant. Vendor’s personnel shall be present during the test. Any malfunctioning of the system components shall be replaced/repaired as required. Para 2.1.6 of this specification shall be applied for failure of components & readjustments. Once the system failure is detected, the acceptance test shall start all over again from the beginning. The warranty period commences from the day owner takes over the system.

6.0 TESTING/CALIBRATION EQUIPMENTS

6.1 Vendor shall make available all consumable, instruments, and equipments necessary for testing, calibration, maintenance etc. as required by the defined scope of works. All instruments and equipments used for the above purpose shall be of standard make with accuracy better than the accuracy expected from the calibrated/tested instruments, and certified by National Physical Laboratory or other equivalent agencies. These instruments/equipments are necessary only during testing/calibration/maintenance.
PART - III

GENERAL REQUIREMENTS

OF

DISTRIBUTED CONTROL SYSTEM
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1.0 SCOPE

1.1 This specification defines the general requirements expected to be fully complied by Distributed Control System vendor including logistic supports, documentation, warranty, maintenance contract and shipping instructions etc.

1.2 The requirements defined in this specification shall also be applicable for all sub-system and hardware bought and supplied by vendor from manufactures other than his own.

2.0 LOGISTIC SUPPORT SERVICES

2.1 The hardware maintenance engineers shall be trained for module level nd optionally component level diagnostics of the system. Vendor is required to quote separately for these training facilities. It is also necessary to include in the proposal the details of diagnostic software package for isolating the fault at module level for all the sub-system of Distributed Control System.

2.2 Training

2.2.1 The requirements of training for owner/consultant personnel (one group consisting of operators and other group consisting of hardware/software maintenance engineers) in the operational software and diagnostic programs, are set forth herein.

2.2.2 Vendor shall be responsible for furnishing details of course outlines, manuals of training, equipment necessary to conduct the training, exercises to evaluate trainees’ progress. Vendor shall also be responsible for any other requirements necessary to train the engineers deputed by owner within a time limit so that they acquire the necessary expertise to operate and maintain the programs and the equipments supplied.

2.2.3 Owner/consultant or his authorised representatives shall select personnel for training on the basis of his requirements and will review all materials furnished for adequacy of teaching aids and time tables.

2.2.4 Training Personnel.

Each instructor-designate shall have the following minimum qualifications for his area of instructions:

a) Six months of formal class-room instructor experience.

b) Complete and thorough technical knowledge of the equipment and system supplied under the contract and skilled experience in their programming, maintenance and operation.

c) Complete and thorough knowledge of the test and laboratory equipment maintaining, diagnosing, programming, operating and trouble shooting the hardware software system.

2.2.5 Course contents

2.2.5.1 The outline of each course shall give the subject matter, a short resume of the pre-requisite subjects (if applicable), the position of the course in the training programme, the aim and yardsticks for evaluation and other topics which will add to the usefulness of the program. In order that the selected trainees shall have time to participate in the course, sufficient advance notice of minimum 8 weeks shall be given by the vendor. The course outlines shall be submitted 10 weeks ahead for review.
2.2.5.2 The training exercise shall be designed to be objective in nature and shall include trouble shooting exercises on similar equipments.

2.2.6 Training manuals

2.2.6.1 All training manuals shall be prepared by the vendor and submitted for review 10 weeks ahead of the commencement of the course. After course completion, these manuals shall become the property of the owner. Any change in equipment, manuals and other material shall be informed to the owner during the guarantee period. In addition to vendor documentation, the following minimum requirements shall be adhered to for the training manuals:

a) Functional flow-charts, descriptive material, program source listings applicable to all operating and application software and diagnostics programs.

b) Schematic drawings of each assembly of the hardware for the course on maintenance.

c) All manuals pertaining to procedures, specifications and operation for each equipment.

2.2.7 DCS hardware and software maintenance training

2.2.7.1 Vendor shall conduct a course in hardware (module level and optional component level) maintenance, software maintenance and diagnostic of the system for owner at vendor’s facility. The course shall be conducted prior to the factory system performance tests so that trained personnel can participate effectively in the final testing.

2.2.7.2 The hardware maintenance training course shall cover every equipment item supplied as part of the Distributed Control System. This course shall include:

a) Actual operation, detection and correction of faults in equipments.

b) Familiarisation with maintenance procedures for the system offered.

2.2.7.3 Some of the topics covered in the course shall include:

- Fundamentals of the system
- Equipment logic diagrams
- Diagnostic procedures
- Peripherals maintenance
- Preventive maintenance procedures

2.2.7.4 Software maintenance training shall cover all software supplied with the system. The trained personnel shall be able to write and debug the application and system software.

2.2.7.5 The vendor is required to quote for in-house and on-site training separately and manhour rate for additional training, if required by the owner.

2.2.8 Site training facility and training kit

2.2.8.1 The training kit shall essentially be used for refresher and training courses for process engineers, operating and instrument maintenance staff. The training kit shall be simple control system with process simulator for a group of loops and shall include:

a) An operator console with a VDU, operator key board and engineering keyboard.
b) Controller with auto backup facility.
c) One each of the varieties of PCBs used in data acquisition.
d) Signal simulator.

2.2.8.2 Vendor to provide the details of the kit offered along with the proposal.

2.2.8.3 Training kit system shall be stand alone with respect to hardware and software and in no way be lined with the main system.

2.3 Spare parts

2.3.1 Vendor shall include in the proposal, provisions for special tools, test equipments and initial stock of maintenance spares for a period of two years after commissioning as are essential for proper maintenance and operation of the equipment. In addition, estimated requirements of spares consumption per annum should also be indicated. Full particulars of the tools, test equipments and spare parts shall be provided separately. The list should also include the item wise price.

2.3.2 The successful vendor shall warrant that spare parts for the system would be available for a minimum of fifteen years. After this period, if vendor discontinues the production of spare parts, vendor shall give at least twenty four (24) months notice prior to such discontinuation so that the owner may order his requirements of spares in one lot.

3.0 DOCUMENTATION

Vendor shall furnish all the manuals necessary to test, operate and maintain Distributed Control System hardware and software.

3.1 Hardware documentation

3.1.1 The following documentation for all hardware supplied and as built under this contract shall be submitted for review two months before the start of factory acceptance testing.

a) The specifications for all off-the-shelf hardware manufactured by vendor, his sub-contractors or suppliers. Supplier’s name and identification of ordered hardware and expected delivery data to vendor’s premises shall also be supplied along with this.

b) Documentation relating to off-the-shelf hardware and hardware developed by vendor including description, specifications, theory of operation, maintenance procedures, installation information and drawings. This information shall exclude all non-applicable information.

c) Where more than one size, rating or type of construction appears on the submitted catalogue data, those characteristics applicable shall be identified. Non applicable information shall be suppressed.

d) Test plans and test reports as specified in Part II of this specification for each item of hardware, to be supplied.

e) Bill of material listing all hardware to be supplied including manufactures part numbers, name plates data, approximate volume, weight and overall dimensions.

f) Spare parts catalogue for all items (at component level) to be supplied.
g) Recommended spare parts for two years.

3.2 Software documentation
The following documents shall be submitted for review before 90 days of the shipment of the system, for the software packages included in the supply:

a) The specifications for all software to be obtained in-house or from subcontractors or suppliers. The details supplied shall also include the name of the suppliers, software identification including latest modification data.

b) Reference manuals, operating manuals, programming manuals and other software manuals (if any).

c) Description of the function of each program. This shall include the logic, configuration requirements and constraints and sub-programs used, memory map and special characteristics.

d) Input and output details for each program.

e) Listing of assembled programs with label and symbol tables in assembler/compiler language.

3.3 System manuals

3.3.1 Manuals shall be submitted for assuring satisfactory operation and maintenance of the system. Detailed literature for installation and maintenance of all hardware should be provided to the owner.

3.3.2 All system manuals shall be supplied in hard cover loose ring folders in A size i.e. 216 x 279 mm. All drawings and sketches shall be in multiple of ‘A’ size like ‘B’ (279 mm x 432 mm) or ‘C’ type (406 mm x 518 mm) etc. but folded to ‘A’ size.

3.3.3 Instruction Manual

The information submitted shall preferably be in three parts.

I Part
First part shall give the following information:

a) A general functional description of the whole system.

b) General software description.

c) General Instructions and start up procedures.

II Part
Second part shall describe the system software in detail including its interaction with application programs and other programs used as supporting software.

III Part
The third part shall include detailed maintenance information including all data pertaining to equipment required for maintenance of the system.

3.3.4 Maintenance manuals

3.3.4.1 The maintenance manual shall include details of
a) Preventive maintenance procedures.
b) Trouble shooting procedures including failure analysis.

3.3.4.2 A section on repairs shall provide enough information on repairs including removal, repairs, adjustment and replacement.

3.3.4.3 The maintenance manuals shall contain a list of all maintenance parts to facilitate quick identification of the parts for replacement and ordering. Standard hardware structural parts, or other parts not requiring maintenance shall not be included here. At the end of the list of parts requiring maintenance, a list of special tools required for the maintenance of each unit shall be given. List of manufacturers of each part shall also be included.

3.3.5 The final system manuals shall be furnished to owner within a month of completion of final satisfactory field testing. All field modifications shall be incorporated and system as built drawings and documents shall be included. Fifteen copies of each manuals shall be submitted to the owner/consultant.

3.3.6 Engineering drawings

3.3.6.1 The vendor shall provide a complete set of drawings covering each art of the supply for the owner/consultant record. The vendor is required to include owner’s project number on each of his drawings in order to ease owner/consultant’s record keeping.

3.3.6.2 Functional schematics and logic diagrams are furnished by owner/consultant to provide an idea of system hardware and software requirements to the vendor. Functional schematics shall be furnished in two parts.

a) Part-I, containing all system hardware and software requirements is furnished along with Material Requisition.

b) Part-II, containing the field devices details like transmitter, junction box details, final actuating device single and multi cable/core details, shall be furnished later. Vendor shall develop loop wiring diagrams, containing full information of each loop (one drawing per loop) including field termination, junction box details, cables numbering, rack number, bus address code, device address code, power supply connections, final actuating device details including positioner and air supply etc and furnish these before the installation of system.

3.3.6.3 All field modifications shall be carefully recorded by the vendor’s commissioning personnel and change shall be incorporated into final drawings. Fifteen copies of each drawing shall be submitted with one reproducible.

4.0 WARRANTY

4.1 Vendor shall be fully responsible for the manufacture in respect of proper design, quality, workmanship and operation of all the equipment, accessories etc. supplied by the vendor for a period of 18 months from the date of taking over by the owner at the site as mentioned in this specification or 24 months from the shipment date whichever is later.

4.2 It shall be obligatory on the part of vendor to modify and/or replace any hardware and modify the operating, application and diagnostic software free of cost, in case any malfunction is revealed even during on line operation after taking over within the warranty period.
4.3 Vendor shall also provide the total maintenance of the system during warranty period. The cost for warranty maintenance, if any, shall be included in the proposal separately in 'vendor proposal outline and pricing details'.

**5.0 MAINTENANCE CONTRACT**

5.1 Vendor shall quote separately for maintenance contract after warranty period for two years based on per day rate for each category of personnel required. The personnel deployed shall have thorough knowledge of the system and at least two years of experience on the maintenance of similar systems. Any other conditions of contract required by vendor shall be explained in the offer.

**6.0 PACKING AND SHIPPING INSTRUCTIONS**

6.1 All the material used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be of recognised brands and shall conform to the best standards in the areas for the articles which are packaged.

6.2 Workmanship shall be in accordance with best commercial practice with the requirement of applicable specifications. There shall be no defects, imperfections or omissions which would tend to impair the protection offered by the package as a whole.

6.3 The package shall be suitable for storing in tropicalised climate, the ambient conditions being specified in the job specifications.

6.4 Shipment shall be thoroughly checked for completeness before final packing and shipment.
OPERATOR STATIONS, ENGINEERING STATIONS, SERVERS SHALL BE AS PER ITB
Following shows the minimum requirement of the control system, any extra systems required to fulfil the requirements shall be in scope of bidder

Independent Racks for each STG
All serial communications shall be redundant (R)
TCP- Turbine control Panel
STANDARD SPECIFICATION

FOR

PROGRAMMABLE LOGIC CONTROLLER (PLC)
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AC</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>API</td>
<td>American Petroleum Institute</td>
</tr>
<tr>
<td>SIS</td>
<td>Bureau of Indian Standards</td>
</tr>
<tr>
<td>CCOE</td>
<td>Chief Controller of Explosives</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing System</td>
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<tr>
<td>DC</td>
<td>Direct Current</td>
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<tr>
<td>DCS</td>
<td>Distributed Control System</td>
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<tr>
<td>DGMS</td>
<td>Director General of Mines Safety</td>
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<tr>
<td>DMR</td>
<td>Dual Modular Redundant</td>
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<tr>
<td>DVD</td>
<td>Digital Versatile Disc</td>
</tr>
<tr>
<td>EMI</td>
<td>Electromagnetic Interference</td>
</tr>
<tr>
<td>ERTL</td>
<td>Electronic Regional Testing Laboratory</td>
</tr>
<tr>
<td>ESD</td>
<td>Emergency Shutdown System</td>
</tr>
<tr>
<td>FAT</td>
<td>Factory Acceptance Test</td>
</tr>
<tr>
<td>FMEDA</td>
<td>Failure Modes, Effects and Diagnostic Analysis</td>
</tr>
<tr>
<td>HART</td>
<td>Highway Addressable Remote Transducer</td>
</tr>
<tr>
<td>HW</td>
<td>Hardware</td>
</tr>
<tr>
<td>HWC</td>
<td>Hardwired Console</td>
</tr>
<tr>
<td>I/O</td>
<td>Input / Output</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronic Engineers</td>
</tr>
<tr>
<td>IS</td>
<td>Indian Standards</td>
</tr>
<tr>
<td>ISA</td>
<td>International Society of Automation</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
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<tr>
<td>LAN</td>
<td>Local Area Network</td>
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<tr>
<td>LCD</td>
<td>Liquid Crystal Display</td>
</tr>
<tr>
<td>LCIE</td>
<td>Laboratorie Central Industries Electriques</td>
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<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>MTBF</td>
<td>Mean Time Between Failure</td>
</tr>
<tr>
<td>MTTR</td>
<td>Mean Time to Repair</td>
</tr>
<tr>
<td>OPC</td>
<td>OLE for Process Control</td>
</tr>
<tr>
<td>P&amp;ID</td>
<td>Piping and Instrumentation Diagram</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>PESO</td>
<td>Petroleum and Explosives Safety Organisation</td>
</tr>
<tr>
<td>PID</td>
<td>Proportional, Integral and Derivative</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>PTB</td>
<td>Physikalisch Technische Bundesanstalt</td>
</tr>
<tr>
<td>QMR</td>
<td>Quadruple Modular Redundant</td>
</tr>
<tr>
<td>RFI</td>
<td>Radio Frequency Interference</td>
</tr>
<tr>
<td>SAT</td>
<td>Site Acceptance Test</td>
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<tr>
<td>SER</td>
<td>Sequence of Event Recorder</td>
</tr>
<tr>
<td>SIL</td>
<td>Safety Integrity Level</td>
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<tr>
<td>SIS</td>
<td>Safety Instrumented System</td>
</tr>
<tr>
<td>TCP / IP</td>
<td>Transmission Control Protocol /Internet Protocol</td>
</tr>
</tbody>
</table>
TFT : Thin Film Transistor
TMR : Triple Modular Redundant
TUV : Technische Überwachungsvereine
UHF : Ultra High Frequency
UL : Underwriter's Laboratories
UPS : Uninterrupted Power Supply
VDU : Video Display Unit
VHF : Very High Frequency

Triple Modular redundant (TMR), Quadruple Modular Redundant (QMR) configuration, Flexible Modular Redundant (FMR) configuration, Virtual Modular Redundant (VMR)
<table>
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1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the Material Requisition defines the minimum functional requirements for the design, hardware, software and firmware specifications, nameplate marking, testing and shipping of Programmable Logic Controllers (PLC) designed for reliable effective and optimum control and monitoring of a process plant. 1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry:

APIRP 552 Transmission Systems
EN 10204 Metallic Products - Types of Inspection Documents
EN 50039 Electrical Apparatus for Potentially Explosive Atmospheres: Intrinsically Safe Electrical System 'I'
IEC 60079 Electrical Apparatus for Explosive Gas Atmosphere
IEC 60529 Degree of Protection Provided by Enclosures
IEC-60584 Thermocouple Part 2: Tolerances
IEC 60617 Graphical Symbols for Diagram
IEC-60751 Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors
IEC 61000-4-3 Electromagnetic Compatibility (EMC) - Testing and Measurement Techniques - Radiated, Radio Frequency, Electromagnetic Field Immunity
IEC-61000-4-4 Electromagnetic Compatibility (EMC) - Testing and Measurement Techniques - Electrical Fast Transients / Burst Immunity Test
IEC-61000-4-5 Electromagnetic Compatibility (EMC) - Testing and Measurement Techniques – Surge Immunity Test
IEC-61000-6-2 Electromagnetic Compatibility (EMC) - Generic Standards - Susceptibility - Industrial
IEC 61508 Functional Safety of Electrical/Electronic / Programmable Electronic Safety-related Systems
IEC 61131 Programmable Logic Controllers
IEC 61511 Functional Safety -Safety Instrumented Systems for the Process Industry Sector

IEEE 802.3 Telecommunication and Information Exchange between Systems -Local and Metropolitan Area Networks -Specific Requirements -Part 3: Carrier Sense Multiple Access with Collisions Detection (CSMA / CD) Access Method and Physical Layer Specifications

IS 2148 Flameproof Enclosures of Electrical Apparatus

IS-3043 Code of Practice for Earthing

IS 13947 Specifications for Low Voltage Switchgears and Control Gears

ISA 5.1 Instrumentation Symbols and Identification

5.2 Binary Logic Diagrams for Process Operations

5.3 Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer System.

5.4 Instrument Loop Diagrams

5.5 Graphic Symbols for Process Displays

18.1 Annunciator Sequences and Specifications

71.01 Environmental Conditions for Process Management and Control Systems: Temperature and Humidity

71.04 Environmental Conditions for Process Measurement and control Systems: Airborne Contaminants

ANSI/ISA Security Technologies for Industrial Automation and Control Systems TR 99.00.01 Manufacturing and Control System

ISO 216 Writing Paper and Certain Classes of Printer matter-Trimmed Sizes-A & B Series

ISO 9241-5 Workstation Layout and Postural Requirements

ISO 9241-7 Display Requirements with Reflections

1.1.3 In the event of any conflict between this specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Design Basis / Statutory regulations

b) Data Sheets
c) Standard Specifications

d) Codes and Standards

1.1.4 In addition to meeting purchaser's specifications in totality, vendor's extent of responsibility shall also include the following:

a) Purchaser's data sheets specify the minimum acceptable functional requirements for the programmable logic controllers. It shall be vendor's responsibility to select proper hardware, software and firmware to meet the specified functional requirements.

b) Purchaser's data sheets specify the scan time / cycle time / response time and loading requirements. Vendor shall be responsible for sizing and selecting their standard product i.e. hardware, software and firmware to meet the requirements specified in the purchaser's data sheets.

c) Selection of proper and adequate hardware, software and firmware to meet system requirements specified in the purchaser's specifications, keeping the integrity of functional blocks specified in the configuration 'diagram attached with the material requisition.

d) Adequacy of Bill of Material selected to meet purchaser's requirements. Vendor to note that bill of material shall not be verified by the purchaser during evaluation stage. Any hardware, software and firmware required to meet the purchaser's specified requirements shall be provided by the vendor without any implication.

e) Providing adequate mandatory spares including consumable spares as specified in the purchaser's specifications. Vendor shall be responsible to meet mandatory spare requirements specified by the purchaser.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition. Vendor's quotation shall enumerate and include the detailed specification of each subsystem and each module of programmable logic controller, detailed system configuration, hardware and software capabilities, programming aids, display facilities and other relevant information.

1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:

a) Compliance to the specifications.

b) Detailed specification sheets for each sub-system. The specification sheet shall provide information regarding hardware specifications, software specifications, redundancy requirements, capacity, power consumption etc. of the programmable logic controllers and its accessories. The material specifications and unit of
measurement for various items in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheets.

c) System security features and design details.

d) Proven references for each offered model in line with clause 1.2.4 of this specification whenever specifically indicated in the purchaser's specifications.

e) A copy of approval for flameproof enclosure, intrinsic safety etc whenever specified, from local statutory authority, as applicable, like Petroleum and Explosive Safety Organization (PESO) / Chief Controller of Explosives (CCOE), Nagpur or Director General of Mines Safety (DGMS) in India along with:

i) Test certificate from recognized house CIMFR (Central Institute of Mines & Fuel Research) / ERTL (Electronics Research and Test Laboratory) etc. for specified protection class as per relevant Indian Standard for all Indian manufactured equipments or for equipments requiring DGMS approval.

ii) Certificate of conformity from agencies like LCIE, Baseefa, PTB, CSA, UL etc., for compliance to ATEX or other recognized standards for all equipments manufactured outside India.

f) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason to deviate from the specified requirement, they must include a list of deviations item wise, summing up all the deviations from the purchaser's data sheets and other technical specification along with the technical reasons for each of these deviations.

g) Certificate for specified SIL requirement (e.g. SIL-3) from Independent Testing Agency.

h) Catalogues giving detailed technical specifications, model decoding details and other related information for each item / sub-system covered in the bid.

1.2.3 Vendor shall offer only their standard proven product i.e. system hardware, system software and firmware, which shall be configured to meet the functional requirements specified in the material requisition. Moreover, the equipment being offered / supplied shall be of latest proven version available in the current manufacturing range and meeting the requirements specified in clause 1.2.4 of this standard specification.

1.2.4 The system hardware, software and firmware as offered, shall be field proven and should have been completed trouble free satisfactory operation for a period of minimum 02 years on the bid due date in the similar application with equal or higher than the proposed system size with respect to number of inputs and outputs specified in the purchaser's data sheet. Items with prototype design or items not meeting proneness criteria specified above shall not be offered or supplied.
1.2.5 The detailed scope of work, specific job requirements, exclusions, deviations, additions etc. shall be indicated in the job specifications which shall be part of material requisition.

1.2.6 Whenever specified, vendor shall furnish tested values of failure rates, probability of failure on demand and test intervals for safety integrity level analysis.

1.2.7 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals shall be in English language only.

1.2.8 Vendor shall also quote for the following:

   a) Two year's operational spares for each sub-system and their accessories which shall include the following as a minimum:

      i) All type of electronic modules e.g. I/O modules, processor modules, communication modules, memory modules, disc controller module, power supply modules etc.

      ii) All type of auxiliary items e.g. barriers / isolators, hardwired instruments, annunciator modules, receiver switches, trip amplifiers, temperature element converters etc.

      iii) Switches, lamps, fuses, connectors, terminals, pre-fabricated cables, circuit breakers, relays etc.

      iv) Video display units, keyboards, disc drives, PC's, network items (e.g. switches, hubs etc.) etc.

   b) Any special tools and test equipments needed for the maintenance of PLCs and other items being offered by vendor. Vendor must confirm in their offer if no special tools or test equipments are needed for maintenance other than those specifically indicated in purchaser's data sheet.

1.3 Drawing and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from thy vendor are indicated by the purchaser in vendor data requirement sheets. The required number of prints and soft copies shall be dispatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design manuals, installation manual, operation and maintenance manual etc., submitted by the vendor after placement of purchase order shall include the following, as a minimum:

   a) Specification sheet for each sub-system, auxiliary instrument and bought out item.

   b) Certified drawings for complete system including the following:
i) GA drawings for panels, cabinets, marshalling racks, hardwired consoles, operator console, programming terminal etc with complete dimensional details, internal construction and weight in kilograms.

ii) Control room layouts e.g. console room, rack room and engineering room layout with all dimensions in millimetres.

iii) Channel base frame drawing for console room, rack room and engineering room.

iv) Input / output assignment.

v) Logic / Ladder diagrams.

vi) Loop wiring diagram.

vii) Power supply distribution diagram.

viii) Memory loading calculations/Scan time calculation.

ix) Protocol/Pin Details.

x) Dynamic graphic diagrams.

xi) System grounding drawing.

c) Design manuals and functional design specifications which shall include hardware design manual, software design manual and special software specifications.

d) Copy of type test certificates.

e) Copy of test certificates for all tests indicated in this specification.

f) Installation manual containing installation procedure for programmable logic controllers and other items covered in the material requisition.

g) Power-on, start-up and internal testing procedures.

h) Software debugging and system configuration procedures.

i) Calibration and maintenance manual containing maintenance procedures including replacement of parts, application modification etc.

j) Any other drawings and documents specifically indicated in job vendor data requirement enclosed with the material requisition.

All system manuals and documentation shall be supplied in hard dover loose ring folders in 'A4' size as per ISO 216 i.e. of size 210mm x 297mm. All drawings and sketches shall be in
multiple of 'A4' size like 'A3' (297mm x 420mm) or 'A2' type (420mm x 594mm) etc. but folded to 'A4' size.

2.0 DEFINITIONS

The various terms used in this specification are defined as follows:

2.1 Programmable Logic Controller

The class of control systems which can be programmed to execute plant shutdown and / or interlock / sequence logics to the specified safety integrity levels.

2.2 Accessible

A system feature that is viewable by and interactive with the operator and allows the operator to perform user permissible control action e.g. set point change, auto-manual transfers or on-off actions.

2.3 Assignable

A system feature that permits an operator to direct a signal from one device to another without the need for change in wiring, either by means of switches or via other data entry devices like keyboard commands to the system.

2.4 Configurable

The capability to select and connect standard hardware modules to create a system or the capability to change functionality or sizing of software functions by changing parameters without having to modify or regenerate software.

2.5 I/O

Input / Output with respect to process / operator

2.6 PLC Console (Operator)

PLC console (Operator) is the operator's main plant interface device through which operator can view, monitor and control the plant and can give instructions to peripherals to execute commands, and shall have protective access to configure and maintain the system.

2.7 PLC Console (Programming Terminal)

PLC console (Programming Terminal) shall be the engineer's main interface device through which engineer can configure / program and maintain the system, and shall have protective access to monitor and control the plant, give instructions to peripherals to execute commands.
2.8 Local Level

All those sub-systems; which directly interface with field devices shall be referred to as local level.

2.9 Central Level

Operator Console and Programming Terminal, which present data acquired from local level devices shall be referred as Central Level.

2.10 Database

Database shall be defined as the information stored temporarily or permanently in the system which can be accessed by various programs to meet all its functional requirements.

2.11 Loop Integrity

A system shall be said to have loop integrity if the failure of one component in the system/sub-system does not affect more than one loop.

2.12 System Loading

System loading for a sub-system is defined as the percentage of time a sub-system spends in carrying out various activities referred to the use of memory, CPU time and communication capacity in the worst case of high sub-system operation out of the designed/designated cycle time of the sub-system.

2.13 Redundancy

A system component shall be termed as redundant if it takes over automatically the operation in the event of the failure of the main component without causing any interruption in the system and upsetting the process. The repaired or replaced device shall be brought in-line only through operator action without upsetting system operation.

2.14 Switchover Time

Time required for a back up instrument/system to come on-line automatically in case of the failure of the main instrument/system.

2.15 Processor Cycle Time (tpc)

Processor cycle time is the measure of the processing speed of a processor. Processor cycle time for a sub-system of the programmable logic controller shall be defined as follows:

Processor cycle time for programmable logic controller shall be defined as the total time taken by the processor to read input supplied by input module, execute all computations...
(analog as well as logic as configured) and write the outputs for the output module.

2.16 Scan Time (ts)

Scan time of a logic loops is the end-to-end response time of a sub-system and shall be defined as follows:

The scan time for a logic loop shall be defined as the total time taken by a sub-system e.g. programmable logic controller to read input from the input terminal, process input, execute logic, updating logic output and write output at the output terminal for all the logics configured within the subsystem.

2.17 User's Memory

Free memory space available after utilisation of memory required for system operation, configuration and implementation of application and other system related functions for implementation of user defined specific programs such as plant calculations, process optimization or MIS (like free formatting of certain logs). The programs shall either be written in high level language or system specific language.

2.18 Event

An event shall be defined as any action taken by the operator via operator keyboard or switches on hardwired console like change of set point, change of control mode, start/stop of motor, open/close of shut down valves, alarm acknowledge etc.

2.19 Sequence of Event (SOE)

Arranging events in the sequence of their occurrence in time with a specified time resolution by a program is defined as sequence of event.

2.20 Sequence of Event Recorder (SER)

System or sub-system which presents and / or records the events in the sequence of their occurrence in time with a specified time resolution utilizing its hardware and software capabilities is termed as sequence of event recorder.

2.21 Real Time Trend

Real time trend shall be defined as a continuously progressing graphical record showing updated parameter with most recent value and a past record of minimum of 10 minutes without pressing any additional key for moving backward in time.

2.22 Plant Information Network

High-level communication network which serves various users within a plant and transfer information for the purpose of unit / plant monitoring. This network is different than control
network and is generally realised using open communication protocol network e.g. OPC etc.

2.23 Tag

A Tag is a collection of attributes that specify either a control loop or a process variable, or a measured input, or a calculated value, or some combination of these, and all associated control and output algorithms. Each tag is unique.

3.0 SPARES PHILOSOPHY

3.1 The system including sequence of event recorder, hardwired instruments etc. shall meet the following spare philosophy. This philosophy shall also be applicable for items like barriers, relays, terminals, lamps, push buttons etc.

3.1.1 Mandatory Spares

Vendor shall include following mandatory spares in their scope of supply:

3.1.1.1 Installed Engineering Spares

Installed engineering spares shall be provided in each sub-system for each type of module to enhance the specified system functional requirements by 20%. The basis of offering installed engineering spares shall include:

a) For a system with conventional and / or smart analog input / output, discrete (contact) input / output, 20% spare input / output of each type shall be considered for calculating I/O modules and all other related accessories.

b) For all serial input / outputs to the system, 20% spare serial I/O ports of each type of serial input / output shall be provided.

c) 20% spare accessories like relays, switches, lamps, fuses, circuit breakers, barriers, isolators, terminals etc.

d) The engineering spares shall be wired up to the field cable interface and shall be in ready-to-operate condition when field cable is connected to spare assigned terminals.

e) Spare pairs of the incoming cables shall be terminated on spare terminals in the marshalling / barrier cabinets as applicable.

f) The system shall be fully engineered considering 20% installed engineering spares including processor loading.

3.1.1.2 Spare Space Requirement

In addition to installed engineering spares specified in Clause 3.1.1.1 of this specification, the
system shall be provided with following spare space:

a) I/O racks of programmable logic controller shall have 10% usable spare space for installing additional I/O cards of each type in future. However internal wiring for the same shall be connected up to the I/O terminals.

b) Processor system of programmable logic controller shall have capability to execute additional 20% logics.

c) Each operator console shall contain 20% usable spare group and related display capability in addition to as specified in para 3.1.1.1 of this specification.

d) The system shall have capability to extend its historical trending, logging and user's memory by 20% to meet future expansion with/without adding additional memory modules.

e) The communication sub-system shall have sufficient capacity to handle additional data contributed by addition of 20% I/O over and above installed engineering spares.

f) Usable spare space in panels and cabinets to install 10% spare hardwired items like relays, switches, lamps, fuses, circuit breakers, barriers, isolators, terminals, panel mounted instrument etc. in future.

3.1.1.3 Spare Memory Requirement

a) The system shall be provided with a minimum of 40% spare memory capacity, as required for application program and data base to meet specified functional requirements.

b) It shall be possible to extend the memory by at least 20% over and above the actual requirement at a later date.

3.1.1.4 Spare Software Capability

a) Sufficient additional software capacity shall be available in the system to take care of spares requirement as specified in para 3.1.1.1 and 3.1.1.2 of this specification to meet all functional requirements as per para 4.0 of this specification.

b) Unless specifically indicated otherwise, the offered system shall have software licenses to cover all the tag numbers indicated in the material requisition, including installed engineering spares and spare space indicated in clause 3.1.1.1 and 3.1.1.2 of this specification.

3.1.1.5 Predefined Mandatory Spares

a) Mandatory spares shall be ware-house spares and shall be supplied as loose
items.

b) Mandatory spare module of 5% or one module of each type, whichever is higher, must be supplied for each type of modules being used excluding modules used in consoles, servers, Personal Computers.

c) For items like, Video Display Units, keyboards, disc drives, network components, hardwired instruments like barriers, lamps, fuses and circuit breakers, complete item limited to 5% or minimum one of each type shall be supplied as predefined mandatory spare. But this shall not include hardware like hard discs, terminals.

3.1.1.6 Consumable Spares

Any paper, ribbon, printer heads, toner and ink required for printers, video copier or any other consumable item shall be supplied along with system required for minimum of six months duration after system acceptance.

3.1.1.7 Commissioning Spares

Unless otherwise specified, vendor shall be responsible to supply all spares which are found necessary to replace failed modules, failed sub-systems, or corrupted / faulty softwares while performing pre-commissioning and commissioning activities.

3.1.2 Two Years Operational Spares

Two years operational spares shall be as per Clause 1.2.8(a) of this specification and shall be quoted separately.

4.0 DESIGN AND CONSTRUCTION

4.1 Design Requirements

4.1.1 Programmable logic controller shall be microprocessor based system which shall be used to execute all the process and safety shut-down logic of the plant. When specified, it shall also execute plant interlock logics and sequence operation. Programmable logic controller shall be an independent unit and shall not depend on any of its functionality on any other system including Distributed Control System.

4.1.2 The system shall be of modular construction and expandable in future by adding additional modules which shall be easily accessible for maintenance and repair. The type of modules shall be kept to the minimum possible in order to have interchangeability and low inventory.

4.1.3 System Availability

a) The system shall be designed 'fault avoidant' as a minimum by selecting high grade components of proven quality and proper design of system electronics.
Redundancy shall be provided, as a minimum, as per this specification to improve system availability and reliability. Due considerations shall be given to the environmental conditions particularly for field mounted sub-system, if specified in job specifications, during system design.

b) The system shall have a high MTBF value and shall have well proven record of operating in hydrocarbon plants.

c) The system shall be designed with 99.995% or greater availability. The availability shall be defined as follows:

\[
\text{Availability} = \frac{\text{Mean Time Between Failure (MTBF)}}{\text{MTBF} + \text{Mean time to repair (MTTR)}}
\]

For the purpose of calculations, consider mean time to repairs as four (4) hours unless the manufacturer recommends higher value for MTTR. It is therefore necessary that:

i) Vendor covers all necessary spare parts in 2 years recommended operational spares which shall be necessary to meet specified MTTR time.

ii) Vendor provides adequate training to owner's personnel and cover all necessary maintenance related topics in their training programmes to ensure specified MTTR time.

### 4.1.4 Operating Environmental Conditions

#### 4.1.4.1 Environmentally Controlled Location Installation

a) All subsystem of Programmable Logic Controllers located in Control Room, Local Control Room or in Satellite Rack Room shall be able to operate satisfactorily from 15°C to 30°C and 20% to 80% non condensing humidity.

b) In addition to above, all such sub-systems shall also be able to operate satisfactorily in case of air conditioning failure with ambient temperature of 50°C and 90% no condensing humidity until the system safe operating limits are exceeded. The minimum period of continuous operation in such condition shall be 48 hours at least once in a month without any damage or degradation of system performance. Vendor, therefore, shall provide continuous temperature monitoring for each enclosed cabinet housing items / equipments generating heat, such as system cabinets, barrier cabinets, relay cabinets etc and also provide alarm for operator alert in case the safe operating temperature limits are exceeded.

c) Chemical filters have been provided in the incoming air conditioning air to limit the concentration of contaminants below following limits:

<table>
<thead>
<tr>
<th>Contaminants</th>
<th>Concentration</th>
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All subsystems of Programmable Logic Controllers located in Control Room, Local Control Room or in Satellite Rack Room shall be able to operate satisfactorily from 15°C to 30°C and 20% to 80% non condensing humidity.
(Corrosive Gases)

SOx  < 0.01 ppm by volume
NOx  < 0.05 ppm by volume
H2S  < 0.003 ppm by volume
Cb   < 0.001 ppm by volume
NH3  < 0.5 ppm by volume
SPM  < 200 ug/m'
RSPM < 100 ug/m'

All sub-systems and system components shall be suitable for operating continuously in the above mentioned corrosive environments

4.1.4.2 Outdoor Installations

a) Sub-systems or system components which are installed outdoor shall be suitable to continuously operate at ambient temperature and humidity specified under ambient conditions. The heat generation effect of current carrying for the electronic modules shall also be considered. For this purpose the system shall be rated for minimum 5 deg C more than the maximum ambient temperature specified. In case the system is not suitable for the above conditions, necessary cooling arrangement shall be provided.

b) Unless otherwise specified, all PLC sub-systems or system components installed outdoor shall have corrosive environmental protection coating meeting the environmental classification class G3 as per ISA-S71.04.

4.1.5 Transient, Static and EMI / RFI Protection

4.1.5.1 The system shall be internally protected against system errors and hardware damage resulting from:

a) Electrical transients on power wiring.

b) Electrical transients on signal wiring.

c) Connecting and disconnecting devices or removing or inserting printed circuit boards in the Programmable Logic Controller (PLC).

4.1.5.2 All sub-systems and system components shall be capable of accepting various signal inputs for its direct use while preventing noise errors due to electromagnetic interference (EMI) or radio frequency interference (RFI) including nearby radio stations, hand held two way radios,
solenoids, relays or contactors carrying heavy currents as per levels of Environmental electromagnetic phenomenon defined in IEC-61000-6-2. The system shall have total noise immunity from UHF / VHF radio communication equipments, (RFI) and (EMI) noise generating equipments as per IEC-61000-4.

4.1.5.3 For interplant, inter unit and other system cables routed in the field, the level of surge immunity required for equipment signal ports shall be increased to level 4 as defined in IEC-61000-4-5 and the system shall operate according to performance criterion B as defined in IEC-61000-6-2.

4.1.6 On-line Replacement

4.1.6.1 On-line replacement of any module of programmable logic controller shall be possible in such a way that removal and addition of the module shall be possible and safe without de-energising the system. Furthermore, there shall not be any interruption of the system while replacing a faulty module wherever redundant modules are provided.

4.1.6.2 Apart from system modules, power supply units shall be replaceable on-line without disrupting the process and without affecting the system redundancies. It shall be possible to hot swap any faulty system module without degrading the system safety or operation or freezing the output status. The switchover to the healthy module shall be bumpless. The swapped module shall take over the function of the failed module without any manual programming.

4.1.7 Electrical Isolation

Galvanic or optical isolation shall be provided for all field signals. The isolation levels shall be as follows:

Analog I/O channel to system ground  1500V AC

Discrete I/O channel to system ground  500V AC

External isolator shall be provided, if necessary to meet the above.

Isolation shall also be provided between Engineering / operator console/PLC programming terminal and related sub-systems connected to it if there is any possibility of high voltage being transmitted to the sub-systems.

4.1.8 Design Requirements of Equipments in Hazardous Area

4.1.8.1 Unless specifically indicated, the field devices are beyond the scope of this specification. However vendor shall be fully responsible for integrating these devices with their system.

4.1.8.2 General requirements

a) Unless otherwise specified, all instruments in hazardous area shall be intrinsically
safe type. Other concepts shall be used when specified.

b) For conventional instrumentation, entity concept shall be used for selecting proper barriers / isolators.

4.1.9 Repeat Signals

4.1.9.1 Unless otherwise specified in the job specifications, following philosophy shall be followed for repeat signals:

a) Whenever repeat contact outputs are required as per job specifications following philosophy shall be followed:

i) For intrinsically safe input contacts, isolating barrier with dual contact output shall be utilized.

ii) For all other contact inputs, repeat contact shall be provided using electromagnetic relays.

4.1.10 The system shall be designed fault tolerant and shall utilize high quality components of proven quality. Any single system fault shall not degrade the system safety or functionality or affect operation. The system shall have certified Safety Integrity Level as per IEC61508/61511 as applicable and specified in job specification. Unless otherwise specified, it shall meet the availability requirement specified in Clause 4.1.3 of this specification.

4.1.11 Unless otherwise specified, the scan time of programmable controller shall be of the order of 250 milliseconds for SIL certified PLCs. Scan time for a PLC shall be as defined under para 2.16 of this specification.

4.1.12 Operation of the PLC shall be completely unaffected by a momentary power loss of the order of 20 milliseconds.

4.1.13 The system shall be programmed in principle as per the logic diagrams furnished during detailed engineering. Vendor shall prepare their own Logic/Ladder diagrams depending upon the capability of the programmable logic controller offered by them. Owner / Consultant reserve the right to revise or review the logic diagrams even after acceptance of any offer. The programming language of offered PLC shall be as per IEC 61131.

4.1.14 Whenever the requirement of SIL is specified for the PLC, it shall meet the requirements of SIL level specified and shall be certified by an independent body (e.g. TUV) for complying requirements of IEC-61508 / 61511 as specified. For shutdown application requiring SIL certification, PLC shall always meet SIL 3 requirements.

4.1.15 The system shall have extensive set of self diagnostics hardware and software for easy and fast maintenance of PLC. Routine checks should run automatically at frequent intervals for identifying any fault in software or hardware. Diagnostics shall be required at local as well as console level.
1.1.16  Safety barriers shall be provided by the vendor for intrinsically safe input/output circuits wherever specified. In such cases, the system shall be designed intrinsically safe based on entity concept. The barriers shall be certified by a statutory authority like Baseefa, LCIE, CSA, UL, PTB, CIMFR etc., for the use in the area classification as specified elsewhere in the job specifications. The proper selection of the safety barriers shall be the vendor's total responsibility. In case of smart transmitter, the entity parameters of the hand held terminals shall also be considered while selecting proper barriers.

1.1.17  Unless otherwise specified all intrinsically safe barriers shall be 3 port isolating type only providing isolation between:

i)  Input and output (non-hazardous to hazardous side of barriers)

ii)  Power supply and input

iii)  Power supply and output

The minimum isolation level shall be 250V.

4.2  System Configuration

4.2.1  General

a)  PLC system configuration / architecture shall be as specified in the job specification. For emergency shutdown system application specified with SIL classification, the system configuration shall be TMR or QMR or DMR or VMR as per the job specification and shall be certified by independent agency e.g. TUV.

b)  Regardless of the action feature selected (except for single architecture), the failure of single component shall not result in a failure of correctly executed safety function. The degradation mode for the selected configuration e.g. 4-2-0 or 3-2-0 or 3-2-1-0, etc. shall be documented in SIL certification report.

c)  In general, the PLC system shall comprise of various sub-systems as described in the subsequent clauses of 4.2.

4.2.2  Input/ Output Subsystem

4.2.2.1  Each I/O module shall have its own processor. I/O modules configured in redundant configuration, shall have their processors properly synchronised.

4.2.2.2  Unless otherwise specified, system shall accept analog 4 -20mA inputs and contact inputs. The maximum number of Input/Output per I/O module shall be limited as per the following table.

<table>
<thead>
<tr>
<th>SI No.</th>
<th>Type of Configuration</th>
<th>Maximum No. I/O s</th>
</tr>
</thead>
</table>
4.2.2.3 Each I/O shall be galvanically isolated from external control circuit by suitable means. The
minimum isolation level between I/O and logic circuit shall be 1000 volts DC.

4.2.2.4 Each I/O shall be protected against the reversal of polarity of the power voltage to I/O.

4.2.2.5 Each input shall be provided with filters to filter out any noise in the input line and contact
bouncing noise, as applicable.

4.2.2.6 All the inputs / outputs shall be double ended i.e. two wires per input / output and not with
common return for all inputs.

4.2.2.7 The interrogation voltage to the inputs and power supply for 2-wire instruments shall be
powered from separate redundant power supply / supplies and shall not be a part of PLC,
unless otherwise specified. This power supply shall be supplied at one point and shall be
distributed by the vendor.

4.2.2.8

a) Each module shall have a LED per channel to indicate the status of each input
output.

b) When specified, input module shall be capable of monitoring the input contacts for
any wire open fault and short circuit.

4.2.2.9 Analog Input Module

a) Input module shall be able to accept 4~20 mA DC input from smart transmitters
(e.g. 4-20mA HART).

b) The module shall have 12 bit Analog to Digital resolution accuracy of ±0.2S% of
full scale over the entire range, unless otherwise specified.

4.2.2.10
a) Output contacts from the PLC shall be potential free dry contacts with contact rating as per para 4.2.2.10 b) of this specification. Vendor must provide arc suppression device for each output contact.

b) The output contact rating shall be as follows:

<table>
<thead>
<tr>
<th>SL.No.</th>
<th>APPLICABLE FOR</th>
<th>VOLTAGE RATING</th>
<th>CURRENT RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All output cards driving solenoid valve and alarm annunciator system unless otherwise specified Category -I</td>
<td>110 V DC 24VDC</td>
<td>0.5 A 2A</td>
</tr>
<tr>
<td>2</td>
<td>All motors/pumps/compressor output cards unless otherwise specified. Category –I</td>
<td>240 V AC 220 V DC</td>
<td>5.0A 0.2 A</td>
</tr>
</tbody>
</table>

(c) The category of contacts shall be specified in the material requisition. Each output shall be short circuit proof and protected by fuse. Visual indication of fuse blown must be provided for each module.

d) When specified contact output module shall have monitored output features like wire open and short circuit.

4.2.2.11 Where inputs or outputs have multiple field devices for the same measurement or device, the corresponding inputs / outputs shall be configured in separate I/O modules.

4.2.2.12 Where single input signal is available for QMR or TMR or FMR or VMR configuration, inputs shall be multiplied to feed inputs to each input modules / channels.

4.2.2.13 PLC shall be provided with Auto I/O testing facility as a standard diagnostics features. PLCs which do not have auto I/O testing facility, manual testing facility shall be provided to detect any system fault. For manual testing, manual switches shall be provided to bypass each input at a time and its effect on the output shall be monitored.

4.2.3 Processor System

4.2.3.1 The processor shall have capability to implement all the control functions required to implement the logic scheme as logic/ladder diagram.

4.2.3.2 The size of the memory shall be sufficient for storage of the program instructions required by the logic schemes and other functional requirements. Offer shall indicate the amount of memory capacity occupied by the actual program and spare capacity available for future program modifications or additions.

4.2.3.3 Memory shall be non-volatile. However in case volatile memory is provided, battery backup shall be provided with a minimum of 3 months lifetime to keep the program storage intact.
battery drain indication shall be provided at least one week before the battery gets drained.

4.2.3.4 Watchdog timer shall be a software device. The healthiness of processors shall be continuously monitored by watchdog timer. Any hardware or software problem in the processor system, which shall include, CPU, memory, power supply, communication interface etc. shall cause the watch dog timer to report processor failure.

4.2.3.5 Wherever dual redundant processor is specified, redundancy shall be provided in such a way that in case of failure of the main processor, the standby shall take over automatically. The changeover shall be bump less. Redundancy shall be provided for complete processor system including processor, power supply and communication sub system.

4.2.3.6 In case of triple modular redundant system all the three processors shall execute the same instructions/program and check their results and vote to correct any faulty result. The faulty processor diagnostic shall be made available.

4.2.3.7 In case of QMR system, individual processor shall execute the same instructions/programs and check their results within same CPU module and majority vote to correct any faulty result. The faulty processor diagnostic shall be made available.

4.2.3.8 Failure of a single processor in dual redundant, triple redundant system and two processors in QMR system shall not affect the system. In case of failure of complete processor system i.e. both processors in case of dual configuration, two or more in case of triple redundant system and more thah two in case of QMR system, outputs shall take failsafe state automatically unless otherwise specified in the data sheets.

4.2.3.10 It shall be possible to generate the first out alarm contact by the PLC in case where a group of parameters are likely to trip a system.

4.2.4 PLC Console (Programming Terminal)

4.2.4.10 The PLC console (Programming Terminal) shall be used for programming, program storing, fault diagnostics and alarm monitoring. Whenever specified, it shall also be possible to use this console for plant operation. The functionality to operate as engineering / programming terminal or operator terminal or both shall be as specified in the job specification.

4.2.4.2 It shall consist of at least one coloured 21" Flat screen LCD monitor with TFT technology and one programming / operating keyboard, mouse and printer unless specified otherwise.

4.2.4.3 PLC console when used for plant operation shall also meet the functional requirements as per clause 4.2.5 of this specification

4.2.4.4 The keyboard shall preferably be touch sensitive sealed type, easy to operate with each key clearly identified.

4.2.4.5 All illegal entries shall be rejected by the terminal and shall be identified by warning signal on
4.2.4.6 Manual forcing of any input or output contact connected to PLC shall be possible from
keyboard. Forced functions shall have an associated audit trail.

4.2.4.7 It shall be possible to modify, add or delete the application program on line without affecting
the outputs.

4.2.4.8 PLC Console shall display logic and/or ladder diagram indicating power flow and shall show
description and status of each contact. It shall also be possible to display process alarms and
diagnostic messages as and when they appear. Further it shall also be able to display I/O
map in a user defined format.

4.2.4.9 It shall be possible to print out the ladder/logic diagram on the dedicated PLC printer. The
printer in addition shall also print out:
   a) The diagnostic messages as and when generated and diagnostic reports, when
called for.
   b) Process alarms connected to the programmable logic controller as and when they
appear and alarm report whenever initiated. The choice of printing alarms on this
printer shall be operator selectable from a key lock / password protected switch on
PLC console.
   c) The I/O maps showing status of all inputs and corresponding outputs in a user
defined format.

4.2.4.10 The PLC console shall be provided with self diagnostics feature which shall display error
messages and initiate an audible alarm if the fault is detected. Wherever specified, a potential
free contact for diagnostic group alarm shall be provided which shall be connected to the
hardwired alarm 'annunciator system.

4.2.4.11 The system shall be able to identify the failure at least up to the module level including I/O
system and redundant processor and report print out.

4.2.5 PLC Console (Operator)

4.2.5.1 Where dedicated PLC operator console is specified, it shall be used for operation of plant,
fault diagnostics, alarm monitoring and report generation.

4.2.5.2 It shall consist of coloured 21” Flat screen LCD monitor with TFT technology, operator
keyboard and printer unless specified otherwise.

4.2.5.3 At least two number cursor control devices shall be provided in addition to keyboard which
may include touch screen, mouse, track ball etc.

4.2.5.4 PLC operator console shall have complete graphic capability and shall be able to display
process dynamic graphics, overview and group view displays. It shall be possible to operate the plant i.e. start and stop of rotating machinery, opening and closing of valves, Pill function etc. from dynamic graphics and group displays available on PLC operator console.

4.2.5.5 It shall be possible to monitor, historise and print out all process alarms, diagnostic alarms and alarm reports.

4.2.5.6 Unless otherwise specified, the time stamping of all alarms shall be as per PLC processor time stamping.

4.2.5.7 The system shall be able to store and display stored data wherever required. The minimum storage capacity shall be for 30 days at 1 minute sample rate for all the inputs specified, diagnostic alarms, process and first out alarms, manipulation data etc.

4.2.5.8 The system shall be able to generate shiftly, hourly, daily, weekly and monthly reports. The log format shall be furnished during detailed engineering.

4.2.5.9 The system shall be supplied with first out alarm generation capability. The resolution of alarm shall be as per processor cycle time, as a minimum.

4.2.6 Communication Subsystem

4.2.6.1 The PLC communication subsystem shall be a digital communication bus that provides a high speed data transfer rapidly and reliably between the processor, I/O sub-system, PLC console and other devices connected in the PLC system.

4.2.6.2 Redundancy in PLC communication subsystem shall be provided as follows unless otherwise specified:

a) For single architecture, the communication subsystem between PLC processor and I/O subsystem shall be single unless otherwise specified. This shall include single communication bus and single interfaces/buffers.

b) For dual I/O configuration, each I/O sub set shall have separate communication interface and bus for connecting to PLC processors.

c) For the triple redundant system, each processor shall have a separate set of PLC communication subsystem.

d) For the QMR systems each I/O subset shall have separate communication interface and bus for connecting to respective CPU module.

e) The communication subsystem between processor subsystem and PLC console shall be dual redundant, consisting of two separate communication interfaces and two buses, each one configured in redundant mode, unless this is only used as programming aid.
4.2.6.3 In case of redundant PLC communication sub system, on the failure of the active device, the redundant device shall take over automatically without interrupting the system operation. Information about the failed device shall be displayed at local as well as on PLC console. It shall be possible to manually switch over the communication from main bus / device to redundant bus / device without interrupting any system function.

4.2.6.4 The mechanism used by the system for error checks and control shall be transparent to the application information / program. Error checking shall be done on all data transfers by suitable codes.

4.2.6.5 In general, PLC shall provide data in a well established protocol format preferably MODBUS protocol.

4.2.7 System Power Supplies

4.2.7.1 Unless specified otherwise, the programmable logic controller shall operate on uninterrupted power supply (UPS). However the system shall be capable of operating satisfactorily at the following power supply specifications:

- **Voltage**: 220 V ±10%
- **Frequency**: 50 Hz±3 Hz
- **Harmonic contents less than**: 5%
- **Power interruption**: 10 millisec

4.2.7.2 The power supply system shall be supplied with dual PLC feeders each capable of handling 100% of the total power supply load requirements. In case of failure of one feeder, redundant feeder shall supply the total load.

4.2.7.3 Each I/O rack shall be provided with separate power supply unless otherwise specified in job specifications. Each power supply shall be sized to take full load of the I/O rack/signal conditioning panel. Each rack shall be provided with dual redundant power supply.

4.2.7.4 Processor subsystem shall be provided with separate power supply, as a minimum, unless otherwise specified in job specification. Failure of one power supply shall not affect the system operation/processor switchover in case of dual processor system. Wherever triple redundant system is specified each processor shall preferably be provided with a separate power supply. Also separate power supply must be provided for each multiplied process I/O channel.

4.2.8 Self Diagnostics

4.2.8.1 The system shall have an extensive set of self diagnostic routines which shall be able to identify all permanent and transient system faults / failures at least up to module level including redundant components and power supplies through detailed VDU displays and
4.2.8.2 At the local level, failure of a module in any subsystem shall be identified by an individual LED.

4.2.8.3 Diagnostic software shall have the capability to provide information about the failed module/system either in the form of a system configuration display or provide information in the form of a "statement".

4.2.8.4 Self diagnostic software shall have capability to detect faults which make the system permanently close/open in the I/O modules or I/O signal conditioning modules (in case of triple redundant system, whenever specified in the job specifications, this may be achieved by automatically running the testing software at cyclic intervals). The automatic cyclic testing feature shall also be provided for dual I/O configuration and dual I/O signal conditioning for triple redundant system. The testing software cycle time may be considered once in 30 minutes however this shall be field adjustable by engineer. However, system performance shall not be degraded whenever testing feature is specified.

4.2.8.5 System for the following functionalities shall be supplied when specified:
   a) Long storage historisation
   b) Log report generation
   c) First out alarm generation

4.2.8.6 System diagnostics shall be capable of identifying, locating and reporting the following faults, as a minimum:
   a) Processor fault
   b) Communication fault
   c) I/O module fault
   d) Power supply fault
   e) Over temperature monitoring
   f) Permanently close / open (stuck on or off) fault
   g) Memory fault
   h) Signal redundancy fault

Any other additional diagnostic alarm if available as a standard shall also be provided by vendor.
4.2.8.7 Testing software shall be capable of detecting faults in case of normally closed system as well as in normally open system.

4.2.8.8 Feedback must be provided in case of triple redundant system and QMR system from the output voter system to detect any latest faults of the system in addition to other diagnostic software.

4.2.9 System Software

4.2.9.1 The system software shall include all programs for the PLC and PLC console which are required to perform all the PLC functions including communication and self-diagnostics. Whenever PLC is specified for shutdown application with SIL classification, the system shall be designed and engineered in full compliance with the requirement of IEC-61511. Whenever different functional logics are combined within a common PLC, the safety related I/O's of each functionality shall be kept segregated within the system.

4.2.9.2 Logic program shall also be recorded on the external electronic media like DVD which shall be delivered in duplicate together with the system.

4.2.9.3 The PLC programming language for implementation of logic operations shall be based on the following representations:

   a) Logic diagrams -Binary logic symbols such as AND, OR, NOT Gates, Timers and Flip-Flops.
   b) Ladder diagram -Series / parallel connection of relay contacts.
   c) Combination of (a) & (b) above.

4.2.9.4 Diagnostic package and its related equipment and software shall be supplied. A list of additional diagnostic packages available and the packages provided, including the description and capabilities, shall be provided with separate quote, wherever asked.

4.2.9.5 It shall be possible to print out the ladder/logic diagram on a dedicated printer. The printer shall also print out all diagnostic reports. Vendor must supply the off line software package to enable the owner to modify/add/delete any part of program and for documentation.

4.2.9.6 Software for the generation of various displays including dynamic graphics wherever specified to be provided as per given below:

4.2.9.6.1 It shall be possible to display dynamic graphic of plant on the operator console VDU screens. Graphic displays shall be field configurable only through PLC Console (Programming terminal) with standard / user defined graphic symbols. Dynamic graphic displays of different sections of the plant shall be displayed on different pages.

4.2.9.6.2 The system shall have graphic symbol library as per ISA-5.1 and 5.3. In addition standard industrial symbols like distillation columns, heat exchangers, pumps, compressors, tanks etc.
shall also provided as a standard.

4.2.9.3 Graphic displays shall be interactive type through which it shall be possible to control the process. It shall also be possible to send motor start/stop and shutdown valve open/close commands, as specified in job specifications, from this display.

4.2.9.4 It shall be possible to view the process variable and alarm points and view and change set point value, manipulated variable, controller mode etc. from the graphic display. Also rotating machinery (i.e. compressor / pump) status and valve status shall be displayed on the graphic display with different colours.

4.2.9.5 Various colours used in the generation of graphics like colour of the process lines, utility lines, Instrument signal lines and event modifier conditions shall be finalised during detailed engineering. The colours used to identify event modified conditions shall generally be as follows unless otherwise indicated during detailed engineering:

- Red - All points alarm
- Blue- Valve open, pump running
- Green - Valve closed, pump stopped
- Flashing green - Shut down valve transition state

4.2.9.6 It shall be possible to go from any graphic page to related graphic pages or any group view or alarm summary in single key stroke using soft key function.

4.2.9.7 The software for printing alarms, system as well as process, and events on the PLC printer must be provided. All alarms must be printed as and when they appear.

4.2.9.8 Software package for displaying I/O map showing status of inputs and corresponding output providing tag numbers as per logic diagram shall be offered. The I/O map format shall be user definable.

4.2.10 **Power Supply Distribution**

4.2.10.1 All type of power supplies shall be made available at one point. Further distribution of power supply shall be in vendor's scope.

4.2.10.2 In general, all output contacts and solenoids shall be powered with 110V±10% DC/ 24V±10% DC power supply. However, the actual interrogation voltages shall be as per job specifications and logic diagrams.

4.2.10.3 The distribution network for interrogation voltage shall be designed such that a single fault in any branch shall not cause trip of the logic other than where the fault has occurred.
4.2.10.4 Sequential starting of various load centers shall be provided whenever specified.

4.2.10.5 Power distribution network must use bus bars of adequate capacity with DPDT (Double Pole Double Throw) switches and HRC (High Rupture Capacity) fuses in each branch network. Vendor may select circuit breaker if short circuit characteristics do not match the HRC fuse.

4.2.10.6 All cubicles lighting shall be on 240 V, 50 Hz AC normal power supply.

4.2.11 PLC System Cabinets

4.2.11.1 All PLC system cabinets shall be completely wired with all modules in place. Inside cabinet wiring shall preferably be done using ribbon type pre-fabricated cables.

4.2.11.2 All the cabinets shall be free standing, enclosed type and shall be designed for bottom entry of cables. Cabinet structure shall be sound and rigid. Cabinet shall be provided with removable lifting lugs to permit lifting of the cabinets.

4.2.11.3 Cabinet shall be fabricated from cold rolled steel sheet of minimum 2 mm thickness suitably reinforced to prevent warping and buckling. Doors shall be fabricated from cold rolled steel sheet of minimum 1.6 mm thickness. Cabinets shall be thoroughly deburred and all sharp edges shall be grounded smooth after fabrication.

4.2.11.4 Cabinet finish shall include sand blasting, grinding, chemical cleaning, surface finishing by suitable filter and two coats of high grade lacquer with wet sanding between two coats. Two coats of paint in the cabinet colour shall be given for non-glossy high satin finish. Colour of the cabinets shall be as per job specification. Final coat shall be given after assembly at site when specified in the job specifications.

4.2.11.5 Each cabinet shall be maximum 2100 mm high (excluding 100 mm channel base), 800 mm wide and 800 mm deep, in general. Construction shall be modular preferably to accommodate 19" standard electrical racks. All cabinets shall be of same height.

4.2.11.6 Cabinets shall be equipped with front and rear access doors. Doors shall be equipped with lockable handles and concealed hinges with pull pins for easy door removal.

4.2.11.7 In order to effectively remove dissipated heat from the cabinets, ventilation fans along with vent louvers backed by wire fly screen shall be provided as required. Ventilation fans shall be provided in all cabinets where the temperature rise with all doors closed and all internal and external loads energised shall exceed 10° C above the ambient temperature. A temperature element (resistance temperature detector) shall be provided in each cubicle for temperature measurement. Ventilation fans shall be provided in dual configuration, as a minimum.

Each fan shall have a separate dedicated assembly and shall be replaceable on-line without shutting down any equipment / panel/cabinet / console in part or in complete. 

Ventilation fan assembly shall operate at 240V AC power supply. Each fan shall have its own dedicated circuit breaker.
Each ventilation fan shall be fitted with a protection type finger guard. Whenever, the numbers of cabinets are compacted (supplied in mechanical joined conditions), each cabinet shall be provided with separate ventilation fan assembly.

The maximum noise level with all fans operating and cubicle doors open shall not exceed 85dBA.

Following signals and alarms shall be provided for each cabinet:

i) Fan failure alarm for each cubicle in PLC.

ii) Temperature indication of each cabinet or compacted combination, as applicable in PLC.

iii) A common alarm each for high temperature and fan-failure shall be made available.

4.2.11.8 Internal illumination shall be provided for cabinets to ensure proper illumination level of 250 lux for performing maintenance activities. Illumination shall be provided for all cabinets by incandescent lamps, which shall be activated individually by door operated magnetic switches. The lamps shall activate when door is opened and deactivate when the door is closed. The magnetic switches selected shall have undergone life cycle cyclic test of at least 1000000 operations. A manual over-ride switch shall be provided inside the cabinet which shall keep the lamp deactivated even when the door is open.

4.2.11.9 Equipment within the cabinet shall be laid out in an accessible and logically segregated manner. Cable glands shall be provided and supplied by vendor for incoming and outgoing cables to prevent excessive stress on the individual terminals. All metal parts of the cabinet shall be electrically continuous and shall be provided with a common grounding lug.

4.2.12 Control Panels/ Hardwired Console

4.2.12.1 Control panels, if required, shall be non-graphic self supporting, free standing cubicle with back doors made up of sectional steel panels. Each section shall be maximum 2100 mm high, 1200 mm wide and 1000 mm deep and shall be mounted on 100 mm high channel base. Care shall be taken to ensure that the face of the panel is truly flat and smooth.

4.2.12.2 Panels / hardwired console shall be fabricated from 3.0 mm thick cold rolled steel sheet. Angle iron frame shall use a minimum section of 50x50x4mm angle.

4.2.12.3 Front of panel/console instrument nameplates shall be black laminated plastic with white core. Nameplate shall be provided on the rear of the panel also for each instrument.

4.2.12.4 Document pocket / wallet shall be provided on the inner side of front and rear doors of each cabinet and on the inner side of the door of each panel. Similar arrangement shall also be made on the inner side of doors of console.
4.2.13 Wiring Requirements'*

4.2.13.1 All wiring shall conform to API RP 552-Transmission Systems. Different signal level cables shall be routed with separation distances as recommended by this code.

4.2.13.2 All wiring inside racks, cabinets, and back of the panels shall be housed in covered, non-flammable plastic raceways arranged to permit easy assembly to various instruments for maintenance, adjustments, repair and removal. \

4.2.13.3 All wiring in the raceways shall be properly clamped. All incoming cable and outgoing cables shall be terminated by vendor at marshalling rack. Total wiring cross-sectional area shall not exceed 50% of the raceway cross sectional area.

4.2.13.4 Separate wiring raceways shall be used for power supply wiring, DC and low level signal wiring, and intrinsically safe wiring. Parallel runs of AC and DC wiring closer than 300mm shall be avoided.

4.2.13.5 Vendor can alternately offer prefabricated cables for interconnection between different cabinets and panels.

4.2.13.6 Wire termination shall be done using self insulating crimping lugs. More than two wires shall not be terminated on one side of single terminal. The use of shorting links for looping shall be avoided.

4.2.13.7 Terminal housing shall be strictly sized with considerations for accessibility and maintenance. Minimum distance required between various components is listed below. These distances are clear distances and are excluding the width of the raceways or any other component / item mentioned herein. Following clearances should be considered:

- a) Distance between terminal strip and side of the cabinet parallel to the strip, up to 50 terminals, shall be minimum 50 mm.
- b) Distance between terminal strip and, top and bottom of the cabinet shall be minimum 75mm.
- c) Distance between two adjacent terminal strips shall be minimum 100 mm.
- d) Additional distance for each additional 25 terminals shall be minimum 25 mm.
- e) Distance between cable gland plate and the bottom of the strip shall be minimum 300 mm.

4.2.13.8 All terminal/terminal blocks shall be DIN Rail mounted type and shall be easily removable. The size of the terminal blocks / terminals of different types shall be consistent and identical. All terminal blocks shall be mounted on suitable anodised metallic or plastic stand-off.

4.2.13.9 No splicing is allowed in between wire/ cable straight run.
4.2.13.10 Terminal strips shall be arranged group-wise for incoming and outgoing cables separately. Terminal blocks for intrinsically safe wiring shall be separate. 20% spare terminals shall be provided, as a minimum, preferably in each terminal strip. Terminals shall be suitable for wires up to 2.5 sq. mm base solid or stranded conductor in general. For power cables, higher size terminals shall be used.

4.2.13.11 Cabinet and rack layout shall be made considering proper accessibility and maintenance.

4.3 Earthing

4.3.1 All system equipments such as panels, marshalling cabinets, system cabinets and other powered equipments shall be provided with following type grounding system:

a) Protective Earth/ Electrical Earth
b) System Earth/ Signal Earth
c) Safety Earth/ Barrier Earth (when required)

Both system earth and safety earth shall be totally separate from protective earth.

4.3.2 Protective Earth / Electrical Earth

a) Each metallic enclosure / cabinet / panel/console etc. shall be provided with electrical earth lug, as a minimum.

b) Unless recommended otherwise by vendor, all earthing lugs of metallic equipments indicated in Clause 4.3.2 (a) above shall be connected individually to electrical protective earthing system bus-bar / earthing station using a maximum of 10sq mm solid copper conductor PVC insulated wires.

c) Where multiple cabinets are multiplexed together, earth looping with permanent shorting link cables shall be acceptable. Two earthing connection wires as indicated in Clause NoA.3.2 (b) above shall be used for connecting multiplexed cabinets to protective earth station / bus-bar.

4.3.3 System Earth

a) System earth shall be totally noise free dedicated earthing system and shall be fully isolated from electrical protective earth. This earth must be very high integrity system and shall be used to ground zero volt references and signal cable grounds.

b) System earth shall be less than one (1) ohm grounding system with its own dedicated earthing pits. These earth pits shall be away from any heavy noise plant equipment. Outside the control room building is the most appropriate location.
c) Wherever supply of earth pit is kept in vendor's scope in the Material Requisition, the earth pit design shall be as per IS-3043 code of practice for earthing. A minimum of four (4) number of earth pits shall be provided for grounding system integrity. In case number of pits required to meet 1 ohm resistance are more than (2), the number of earth pits shall be two times the actual number of pits required to meet resistance criteria. All these pits shall be securely connected with each other to form a one homogeneous system earth grid.

d) Each marshalling / system cabinet / panels etc shall be provided with system earth bus-bar which shall be insulated from the metallic body frame. This bus-bar shall be used to earth also signal zero volt references and signal cable screens. Terminals used for termination of spare conductor pairs / cores of multi-pair signal/control cables shall be connected to system earth bus-bar. Shorting links shall be used for spare terminal looping.

e) System bus-bars in the multiplexed cabinets can be joined together by permanent shorting links. System bus-bars of other cabinets can also be connected together provided they are permanently joined using 35 sq mm stranded copper conductor cable.

4.3.4 Safety Earth / Zener Barrier Earth

a) Whenever Zener barriers are selected or used to meet intrinsically safe requirements, the earthing terminal of the zener barriers shall be connected to a separate earth bus bar.

b) This earth shall meet all the requirements specified in Clause 4.3.3 of this specification.

c) Safety earth bus bar shall be directly connected to earth pits using dual insulated cable. Cable conductor size shall be minimum 95 sq. mm (copper).

4.4 Interface with DCS

The PLC shall be required to be interfaced to the Distributed Control System bus whenever specified. A suitable interface shall be offered in order to achieve the following functions:

a) Display of all input points under alarm/first out alarm connected to PLC or generated by PLC, continuous indication for analog signal on the main DCS operator console.

b) Generate shutdown reports on the logging printer of Distributed Control system.

c) To receive certain operational commands from the operator console for the operation of certain output devices connected to PLC

d) To display diagnostic message of PLC.
In general, PLC shall provide data in a well established MODBUS protocol format.

The interface shall be dual redundant unless otherwise specified.

The speed of data transfer shall be such that any change in I/O which is to be updated on the operator console shall not exceed 3 second from the time event to update on the operator console screen considering one second standard update rate in DCS operator console.

4.5 **Sequence of Event (SOE) Function Requirement**

Sequence of Event, whenever specified, for analog and digital inputs shall be generated and time stamped in PLC. The maximum resolution between two events shall not exceed specified PLC scan time unless specified otherwise. A separate SOE PC with 21" size TFT screen and printer shall be provided for PLC sub-system unless specified otherwise.

5.0 **TESTING, INSTALLATION, COMMISSIONING AND ACCEPTANCE**

5.1 **General**

5.1.1 This specification defines the basic guidelines to vendor for factory testing and acceptance, installation, commissioning and field acceptance of the complete PLC system. On the basis of this specification, vendor shall submit their own detailed testing, installation, commissioning and acceptance procedure. For hardware, the procedure shall include test name, purpose of test, test equipment / set up, definition of input, test procedure, results expected and acceptance criteria. Similarly for software, it shall include test name, details of the method, list of tests, sequence of execution, results expected and acceptance criteria. For PLC system with SIL 3 requirement, certificate for hardware & software (Like TUV etc.) shall be verified.

5.1.2 The testing and acceptance of the system shall be carried out on the approved testing procedures and criteria based on this specification and vendor's standard testing requirements and procedures.

5.2 **Factory Acceptance Tests (FAT)**

5.2.1 Vendor shall test and demonstrate the functional integrity of the system hardware and software. No material or equipment shall be transported until all required tests are successfully completed and certified "Ready for Shipment" by the owner/consultant.

5.2.2 The purchaser reserves the right to be involved and satisfy himself at each and every stage of inspection. The purchaser shall be free to request any specific test on any equipment considered necessary by him although not listed in this specification, as a part of approval of factory testing procedure. The cost of performing all tests shall be borne by the vendor.

5.2.3 Vendor to note that acceptance of any equipment or the exemption of inspection or testing
shall in no way absolve the vendor of the responsibility for delivering the equipment meeting all the requirements specified in Material Requisition.

5.2.4 It shall be vendor's responsibility to modify and/or replace any hardware and modify the software if the specified functions are not completely achieved satisfactorily during testing and factory acceptance.

5.2.5 Schedule of FAT shall be included in the Vendor's proposal.

5.2.6 Vendor shall not replace any system component/module/sub-system unless it is failed. A log of all failed components/modules in a sub-system shall be maintained which shall give description of the failed component/module, effect of failure on the sub-system, cause of failure and number of hours of operation before it failed. If malfunction of a component/module in a sub-system repeats, the test shall terminate and vendor shall replace the faulty component/module. Thereafter the test shall commence all over again. If even after this replacement, the sub-system fails to meet the requirements, vendor shall replace the full sub-system by the one meeting the requirements and the system shall be tested all over again. If a sub-system fails during the test, which is not repaired and made operational within four hours of active repair time after the failure, the test shall be suspended and restarted all over again only after the vendor has replaced the device in the acceptable operation.

5.2.7 Testing and FAT shall be carried out in two phases. The minimum requirements for testing during these two phases shall be as follows:

5.2.7.1 Under the first phase, vendor shall perform tests at his works to ensure that all components function in accordance with the specification for each type of test. A test report shall be submitted for purchaser review within one week of completion of this test. Phase II testing (witness inspection) shall start only after this.

All subsystem shall undergo a minimum of 30 days burn in period. The burn-in time shall start after the sub-system is fully assembled and is powered up. It may include any such time for which the system has been kept powered on even for system generation and Phase I testing.

Following tests shall be performed by the vendor and reports shall be forwarded to purchaser:

a) Quality control test which shall be carried out to assure quality of all components and modules in accordance with vendor's quality control and assurance procedures.

b) System pre-test which shall be physical check of all modules, racks, cabinets etc.

c) System power-up test which shall test functionally all hardware and software. This shall include testing of redundancy, System performance on power supply variations, application software testing and system diagnostic verification.
5.2.7.2 The second phase of testing shall systematically, fully and functionally test all hardware and software in the presence of purchaser representatives. All subsystems shall be interconnected to simulate, as close as possible, the total integrated system. Following minimum tests shall be carried out:

a) Visual and mechanical testing, which shall be carried out in principle to assure correct, proper, good and neat workmanship by the vendor. This testing shall include dimensional verification, Layout verification as per approved GA drawings, Verification of Sheet thickness / Quality of painting (outer and inner) / Nameplates, identifiers and tag plates / Adherence to ferruling philosophy / Dressing of wires / prefabricated cables and clearances / Locks and handles as a minimum.

b) Verification of Bill of Material. The Bill of material verification shall include both hardware and software.

c) Functional testing:

This shall include the simulation of each input and output to verify proper system response. The testing as a minimum shall include:

i) Complete system configuration loading.

ii) Demonstration of all PLC system builder functions including addition/deletion of an input/output, addition/deletion of a rung or an element in a rung, generation of dynamic graphics and other views, report generation etc.

iii) 100% checking of logics configured in the PLC by connecting switch/lamp at input/output, by simulating inputs and verifying outputs preferably using simulator, other related functions like forcing, first out shall also be verified.

iv) Checking of scan time. Scan time verification shall be carried out using high resolution storage oscilloscope during Factory Acceptance Test based on the specified requirements considering discrete input by given step change. The scan time values so observed shall be within 90% confidence level. In case of analog inputs, input shall be ramp or minimal step, however such reading for analog inputs should be noted only for reference.

v) Checking of all PLC console displays, keyboard and touch-screen operation (wherever specified), printer/hard copier functions etc.

vi) System redundancy check including correct change over of the back-up unit in case of failure of main unit.

vii) System diagnostic checking for all subsystems on local level as well as on console, including checking of the testing software for I/O modules/signal conditioning modules, when specified.
viii) Checking of output status on processor failure.

ix) Checking of first-out alarm generation.

x) Simulation of power failure and system restart auto boot-up of system configuration and program after power restoration.

5.2.8 Vendor shall notify the purchaser at least three (3) weeks prior to factory acceptance test. In the event that representative arrives and the system is not ready for testing, vendor shall be liable for back charges for any extra time and expenses incurred.

5.3 Installation, Testing and Commissioning

5.3.1 Vendor shall offer the services of an installation team which would install the equipment in the control room, lay the interconnecting cables inside control room, check-out, test and commission the system.

All technical personnel assigned to the site by the vendor shall be fully conversant with the supplied system and software package, and shall have both hardware and software capability to bring the system on line quickly and efficiently with a minimum of interference with other concurrent construction and commissioning activities.

5.3.2 Vendor's responsibility at site shall include all activities necessary to be performed to complete the job as per material requisition including:

   a) Receipt of hardware/software and checking for completeness of supplies.

   b) Installation of the system including for free supply equipment, if any.

   c) Field cable termination and inter-cabinet cabling and termination.

   d) Check out equipment installation.

   e) Checking of interconnections, hardware and software configuration, overall system

   f) Loop checking.

   g) Field tests.

   h) Commissioning and on-line debugging of the system.

   i) Involvement during plant commissioning and performance of final acceptance test.

   j) Co ordination for integration with DCS / other third party system.

5.3.3 Field Inspection

5.3.3.1 All equipments shall be inspected thoroughly by vendor after its receipt at site for
completeness and proper functioning. Vendor must initiate the remedial action, in case unsatisfactory operation of any item is observed, with intimation to Engineer-in-charge.

5.3.3.2 Vendor must document all observations including details of any malfunction observed. Items/equipments requiring total replacement must document the reasons for the same.

5.3.4 Loop Checking

5.3.4.1 Loop checking shall be carried out by vendor including checking the interconnections, configuration and overall system functioning.

5.3.4.2 Vendor's scope of work as a part of system installation and loop checking shall include termination of field cables in the control room, checking of interconnection between instrument/equipment, glanding, ferruling/tagging of interconnecting cables in control room, ferruling of field cables in control room and performing overall loop performance check.

5.3.4.4 The input signals shall be simulated by disconnecting/connecting the field wires for all field switches connected to ‘PLC. All field transmitters connected to control room shall be loop checked at 0%, 50% & 100% of full scale (for both increasing and decreasing signals). Wherever receiver cards are used, the set point shall be generated by giving the input signal to receiver card. All outputs shall be checked in field, either for actual operation of solenoid valve or actual pick-up of electrical contractor for rotary equipments. Shutdown schemes shall be checked for proper functioning, configuration and actuation.

5.3.4.5 After loop checking is completed, vendor shall connect back any terminals and connections removed for loop checking.

5.4 System Acceptance

5.4.1 The owner shall provisionally takeover the system from vendor after System acceptance test. System acceptance test shall be started only after the satisfactory performance of loop checking and verification of all loop checking records by Engineer-in-charge.

5.4.2 The system acceptance test shall be carried out in the presence of owner's representative and Engineer-in-charge or his authorised representative. The tests carried out in System acceptance test shall be fully recorded and duly signed by all representatives participating in the System Acceptance Testing.

5.4.3 Vendor shall carry out the following functional tests, as a part of system acceptance test, as a minimum.

   a) Hardware verification as per final Bill of Material.

   b) Visual and mechanical check-up for proper workmanship, identification, ferruling, nameplates etc.

   c) System configuration as per approved configuration diagram.
d) Demonstration of all system function, display and diagnostics.

e) Checking of correct change-over of redundant devices.

f) Checking of various peripheral devices like printers and printing of all reports.

g) Complete checking of logic system, loading of user's program and checkout of results.

h) Checking of proper functioning of all disc drives, alarm summary, alarm history etc.

i) Proper information transfer on the information network by verifying system displays and printout.

5.5 Final Acceptance Test

The owner will take over the system from the vendor after the final acceptance test, which is defined as successful uninterrupted operation of the integrated system for three weeks. Vendor's personnel shall be present during the test. Any malfunctioning of the system components shall be replaced / repaired as required. Once the system failure is detected, the acceptance test shall start all over again from the beginning. The warranty period commences from the day owner takes over the system.

6.0 GENERAL REQUIREMENTS

6.1 Vendor shall comply fully with the general requirements of PLC system including logistic support services, documentation, warranty, maintenance contract and shipping instructions.

Post Warranty Maintenance Contract

Vendor shall quote separately for post warranty maintenance contract after warranty period for five years for the complete system as per commercial terms and condition of the requisition and the type (i.e. comprehensive or non-comprehensive) of post warranty maintenance shall be as specified in job specification. The personnel deployed during post-warranty maintenance shall have thorough knowledge of the system and at least two years of experience on the maintenance of similar system. Any other conditions of contract required by vendor shall be explained in the offer.

7.0 SHIPPING

7.1 All the materials used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be of recognised brands and shall conform to the best standards in the areas for the articles which are packed.

7.2 Workmanship shall be in accordance with best commercial practices and requirements of applicable specification. There shall be no defects, imperfections or omissions which would
tend to impair the protection offered by the package as a whole.

7.3 The packing shall be suitable for storing in tropicalised climate, the ambient conditions, being specified in job specifications.

7.4 Shipment shall be thoroughly checked for completeness before final packing and shipment. Vendor shall be responsible for any delay in installation or commissioning schedule because of incomplete supply of equipments.
STANDARD SPECIFICATION FOR

SAFETY RELIEF VALVE
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Safety Valve sizing will be done only after control valve sizing is fixed.

All Safety Valves / Thermal relief valves shall be flanged type, irrespective of licensor's recommendation of NPT.

1.00 General

1.01 This general specification together with the data sheets and inspection standards attached herewith define the technical requirement for the supply of Safety / Relief valves, spares, documentation, inspection-testing and shipping.

1.02 In the event of any conflict between Engineering specification and Instrument specification the later shall prevail.

2.00 Codes and Standards

2.01 The pressure relieving devices design, manufacture, installation and testing shall be in accordance with the following codes and recommendations and as specified in the individual specification sheets:

a) ASME Boiler and pressure vessel code section I
   - Design, manufacture and calculation for steam services in fired pressure vessels.

b) ASME Boiler and pressure vessel code section VIII
   - Design, manufacture and calculation for steam, gas, vapour and liquid services in unfired pressure vessels

c) API-RP-520, part I and II sizing, selection & installation of pressure relieving system in refineries.

d) API standard 521 guide for pressure and depressurising system.

e) API standard 526 flanged steel safety relief valves.
   - Design and manufacture as per ASME section VIII and orifice calculation as per API -RP-520 part I and II , appendix C

f) API standard 527 commercial seat tightness of safety relief valves with metal to metal seat.

g) API 2000 for sizing of pressure / vacuum relief valves on storage tanks.

h) ASME B16.5 steel pipe flanges, flanged valves and fittings.

i) ASME B46.1 surface textures.

j) Indian Boiler Regulations for valves on steam service, Paragraph 293.

k) ASME B16.34 for non destructive tests
3.00 Sizing and Design Criteria

Sizing of safety relief valves shall be in accordance with API RP-520 (latest edition), Indian Boiler Regulations ASME Section I (Power Boilers) and ASME code for Pressure Vessels Section VIII'. The code stamps shall be provided for safety valves in case ASME and Indian Boiler Regulations design.

Safety relief valves shall normally be direct spring loaded types and provided with full nozzle type. Balanced bellows type safety valves shall be provided when variable backpressure exceeds 10% of the set pressure or fluid is corrosive. Pilot operated pressure relief valves shall be used for special services and where set pressure is closer than 10% of the operating pressure, in general. Thermal relief type valves shall be used for thermal expansion of liquid or gas. Vacuum relief type valves shall be used for storage tank. Steam jacket type safety valves shall be used for crystallizing fluid at ambient temperature.

The body material shall, as a minimum, be as per piping specifications. Nozzle and disc material shall be SS316 as a minimum with machined stainless steel guide, and spindle. Whenever semi nozzle designs are unavoidable, body material shall be at least same as nozzle material.

The spring material of pressure relief valves shall be as follows unless otherwise necessary because of process conditions.

-29°C to 250°C : Cadmium/nickel plated carbon steel
Above 250°C : Tungsten alloy steel
Below – 29°C : Stainless steel 316

Flanged connection shall normally be specified

Conventional type safety valves shall have vented bonnets with screwed caps; balanced bellows type safety valves shall be of the yoke type with screw settled caps.

Plain lifting levers shall be provided for steam and air services. Packed lifting levers shall be used when protection against leakage is required.

CONTRACTOR shall submit calculations for all safety relief valves.

All safety relief valves relieving to flare header shall be balanced bellows type only with trims and bellows in SS 316 L.

Pressure relief valves required for liquid service shall have liquid trim with discharge coefficient certified by ASME.

Pressure relief valve body casting and nozzle casting with inlet rating of 600 # and above in Hydrogen service shall undergo Helium leak test.

3.01 The manufacturer shall furnish calculations in accordance with the code specified in the individual instrument specification sheets. Each manufacturer to state its own "K" factor and actual measurable area. In addition, approx. weight of each valve shall be specified.
All the above information shall be submitted at the time of bidding, approval after order placement & along with final despatch.

3.02 The percent over-pressure and accumulation used in calculation for sizing of relieving devices shall be considered as indicated in the individual specification sheet.

3.03 For Steam, BFW & condensate services the instrument shall be IBR certified. For items of foreign origin the certification shall be done by Lloyds or any other IBR approved authorities in specific IBR format.

3.04 Wherever NACE certificate requirement has been specified in Instrument specification, the material composition & hardness tests shall be conducted only as per MR-0175 latest edition. The tests shall be carried out in an approved laboratory.

3.05 For corrosive services like UREA wetted parts of stainless steel 316L grade and Cr-Ni-Mo 25-22-2 alloy shall be used. For these materials chemical analysis and corrosion tests (Huey test) shall be carried out as per ASTM A 262 'practice C'. The tests shall be carried out in an approved laboratory.

3.06 All safety valves of inlet rating 900# and above shall be subjected to radiography/ultrasonic test as per procedures outlined in ASME-B16.34 and mutually agreed quality assurance plan, if not otherwise stated in the individual specification sheet.

3.07 Safety / relief valves for thermal expansion (on liquids) shall be flanged type. Thermal relief valves shall be flanged with Inlet 1" 600# RF and outlet 2" 150# RF with typical "D" designation and typically 0.38 cm² orifice size.

3.08 All valves except thermal relief ones shall be full nozzle type. All valves shall have the facility of blow-down adjustment except thermal relief valves. Base/modified or semi-nozzle types shall be specified for thermal relief valves.

3.09 Lifting Levers shall be furnished for exposed spring bonnets on valves in steam and hot water service, on air and hot water valves with closed bonnets. All the lifting levers shall be packed type unless the valve is handling inert gas at ambient temperature.

3.10 Bonnets shall be plain closed ones for toxic or inflammable gases as well as for vapours and liquids. Exposed spring bonnet shall be specified for steam service and in boiler feed water service above 200°C. Extension type of bonnet shall be used above 400°C & cryogenic service.

3.11 Balancing or Sealing Bellows shall be used under the following conditions or as specified in the individual specification sheet.

a) When the back pressure exceeds 10% of the set pressure.

b) The back pressure is variable.

c) The valve is handling corrosive fluid.

3.12 Material Of Valve Body shall conform to the material specified in the enclosed individual instrument specification sheets. In general valve body material and rating shall conform to upstream line specification or specification of the vessel wherever it is mounted.

3.13 Material of nozzle and disc shall be, in general, SS 316 (A182 F316) and 17.4 pH or 316SS with stellite facing if not otherwise stated in the individual instrument specification sheets.
3.14 Springs shall be carbon steel cadmium plated (rust proof) for normal process operating temperature (-) 25°C to 200°C and tungsten/ alloy steel for high temperature above 200°C. Below (-) 25°C stainless steel may be used. Carbon steel (Rust proof) is permitted above 200°C when the bonnet is open.

3.15 Test Gag shall be furnished on all safety and relief valves and they shall be handed over to owner after testing clearly labelled with the tag number of the valve they belong to.

3.16 The manufacturer must specify Cold Differential Set Pressure (CDSP) for each pressure relieving devices at 25°C.

3.17 Rupture disc if specified used at inlet of safety valves shall have fragmentation free burst. The stamped capacity of safety valves shall be derated by 20%, unless the combined capacity of the rupture disc and safety relief valve is established by the disc manufacturer.

3.18 The space between safety valve and rupture disc shall be vented during normal operation. The disc holder shall be supplied with 4” telltale pressure gauge with SS body, wetted parts, pipe nipple, excess flow valve. The excess flow valve and pressure gauge shall have 1/2” NPT connections.

3.19 Burst sensors with rupture discs in hazardous areas shall either be ex-proof or intrinsic safe confirming to area classification & execution specified against each item in the individual specification sheets.

Ex-proof certification confirming to CENELEC, FM, BASEEFA and IS is preferred. IS - 2148 certification must be supplemented with the temperature classification certification confirming to IS - 8239.

Intrinsic safe certification shall in general confirm to CENELEC standard EN 500014 and EN 50020, if not otherwise specified in the individual specification sheet.

3.20 Components made of copper and copper alloys exposed to atmosphere and coming in contact with the operating fluid must not be used for ammonia & urea services.

3.21 All pressure relief valves in oxygen and chlorine service shall be thoroughly degreased using reagents like trichloro-ethylene or carbon tetrachloride. End connections shall be blinded/plugged after this degreasing process to avoid images of oil particles.

**Pilot Safety Valves**

- For pilot operated valves, the pilot design shall be of inherently fail safe.
- Unless specified otherwise, pilot shall be non-flowing type.
- All accessories like back flow preventer, pilot filter etc. required for proper operation of pilot operated valves as per indicated service conditions shall be included.
- Material of construction of pilot shall be same as that of main valve nozzle as a minimum.
- The o-ring and diaphragm material of pilot shall be suitable for the pressure and temperature conditions specified in the data sheet.
4.00 Inspection, Factory tests and approval

4.01 Within two weeks of receipt of the LOI/order the vendor must contact the Inspection Agency specified in the order and finalise with them the Quality Assurance Plan for carrying out Inspection and test. In absence of any Inspection Agency the vendor must submit the quality Assurance Plan for OWNER’s approval. All tests, in such cases, shall be conducted by vendor’s Quality Department and the results of tests shall be forwarded alongwith the supply.

4.02 The manufacturer shall give clear 15 days notice informing readiness of the valves at manufacturer’s works.

4.03 The vendor shall permit the authorised representative of OWNER to inspect the manufacture and assembly of the valves in various phases in compliance with approved drawings, standards and specifications.

4.04 The vendor should make available to the authorised inspector the results of all the checks/calibrations conducted before presenting for Owner’s inspection.

4.06 The vendor to provide all necessary facilities free of cost to Owner's inspector for carrying out the checks/calibration as per standard/approved quality assurance plan. In no condition inspection can be waived off without the written permission of Owner.

4.07 No assembly shall be shipped until all the required tests are successfully completed and certified “Cleared for despatch” by the inspection authority.

4.08 The following tolerances are permitted for calibration:

   a) For valve calibration < 5 kg/cm², +/- 2.8% of the calibrated value.
   b) For valve calibration > 5 kg/cm², +/- 3% of the calibrated value.

4.09 The following tests shall be carried out as a minimum for safety valves

   (i) Verification of cold differential test pressure 100% for all valves
   (ii) Hydraulic pressure tests for primary parts (Refer ANSI B 96.1 for terminology) shall be tested at 1.5 times the set pressure.
   (iii) Pneumatic shell test for closed bonnet valves on secondary side shall be at 1.5 times back pressure (or) 2 kg/cm² whichever higher when back pressure is zero or not stated. For positive back pressure test pressure shall be 1.5 times the back pressure.
   (iv) Seat leakage test for metal to metal seated safety valves shall be done in accordance with API-527. For steam, soft seat, pilot valves and special cases where leakage test is not covered in API-527, the procedure for testing in such cases shall be mutually decided and recorded in the Quality assurance plan.
   (v) Foundry /forge shop test certificate to be provided for verification of body, bonnet, nozzle for conformance to standards.
   (vi) Vendor’s test certificate for material conformance and pressure test to be provided.
   (vii) IBR certificate wherever applicable. Refer clause no. 3.03
(viii) Radiography/Ultrasonic inspection. Refer clause no. 3.06

(xi) NACE certificate wherever applicable. Refer clause no. 3.04

(xii) Corrosion test (Huey test) wherever applicable. Refer clause no. 3.05

(xiii) Sealing test on bellows (as per manufacturer’s standard)

4.10 Test certificate verification for coefficient of discharge

5.00 Packing

Each safety / relief valve and its accessories wherever applicable shall be suitably packed and protected from damage due to transportation, loading and unloading.

The safety / relief valves along with their spares shall be despatched as a single consignment.

6.00 Identification and Marking

6.01 Each safety / relief valve shall be fitted with a stainless steel permanently fixed name plate with the following minimum information:

- Complete tag no of the valve as per inst. data sheet.
- Manufacturer’s name
- Valve model and serial no.
- Inlet and outlet sizes with ratings
- Body and trim material
- Bellows material wherever required
- Designated orifice with area in sq. cm.
- Set pressure in kg/cm².

All valves are applied two coats of red oxide metal primer, prior to applying two final coats of synthetic enamel paint. The second coat of synthetic enamel paint is applied just before despatch.

7.00 Spares

Spares shall be as per enclosed spares list separately attached.

8.00 Documentation
The following documents (Technical) are required to be submitted by the vendor alongwith bid, after placement of order for approval purposes and final documentation before despatch of consignment.

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<th>SL. NO.</th>
<th>DESCRIPTION OF DOCUMENT</th>
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<th>FINAL DOCUMENTS BEFORE DESPATCH OF CONSIGNMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Consolidated list of drawing &amp; documents.</td>
<td>Yes</td>
<td>Yes(I)</td>
<td>Yes</td>
</tr>
<tr>
<td>2.</td>
<td>Catalogue &amp; technical literature of safety valves alongwith sizing calculation.</td>
<td>Yes</td>
<td>Yes(I)</td>
<td>Yes</td>
</tr>
<tr>
<td>3.</td>
<td>Deviation if any, from the technical spec. giving justification for the same.</td>
<td>Yes</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4.</td>
<td>Dimensional and sectional drawing against each tag showing material of construction of each part.</td>
<td>Yes</td>
<td>Yes(I)</td>
<td>Yes</td>
</tr>
<tr>
<td>5.</td>
<td>Capacity chart for safety/thermal relief valves showing set pressure effective area/for air capacity, water capacity against models offered.</td>
<td>Yes</td>
<td>X</td>
<td>Yes</td>
</tr>
<tr>
<td>6.</td>
<td>Chemical analysis and material test certificates from an approved laboratory.</td>
<td>X</td>
<td>X</td>
<td>Yes</td>
</tr>
<tr>
<td>7.</td>
<td>Certificates showing chemical analysis, corrosion test (Huey test), Ferrite content on finished product, where applicable from an approved laboratory.</td>
<td>X</td>
<td>X</td>
<td>Yes</td>
</tr>
<tr>
<td>8.</td>
<td>NACE certificate (wherever applicable) from an approved laboratory.</td>
<td>X</td>
<td>X</td>
<td>Yes</td>
</tr>
<tr>
<td>9.</td>
<td>Weight of safety / relief valves.</td>
<td>Yes (approx. weight)</td>
<td>Yes(I)</td>
<td>Yes</td>
</tr>
<tr>
<td>10.</td>
<td>Instruction Manual for maintenance.</td>
<td>X</td>
<td>X</td>
<td>Yes</td>
</tr>
<tr>
<td>11.</td>
<td>Calibration and performance test certificates including calibration curve &amp; Cold diff. test pressure values.</td>
<td>X</td>
<td>X</td>
<td>Yes</td>
</tr>
<tr>
<td>NO.</td>
<td>DOCUMENT</td>
<td>BID</td>
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<td>-----------------------------------------------</td>
</tr>
<tr>
<td>12.</td>
<td>IBR certificate for valves for steam, BFW and condensate services from statutory bodies wherever applicable.</td>
<td>x</td>
<td>x</td>
<td>Yes</td>
</tr>
<tr>
<td>13.</td>
<td>Ultrasonic test certificates for steel forgings and bars wherever applicable</td>
<td>x</td>
<td>x</td>
<td>Yes</td>
</tr>
<tr>
<td>14.</td>
<td>Liquid diepenetrant test certificate for steel castings and forgings.</td>
<td>x</td>
<td>x</td>
<td>Yes</td>
</tr>
<tr>
<td>15.</td>
<td>List of routine tests performed on standard valves and suggested on special ones.</td>
<td>Yes</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>16.</td>
<td>Radiography inspection certificate for steel castings and forgings wherever applicable.</td>
<td>x</td>
<td>x</td>
<td>Yes</td>
</tr>
<tr>
<td>17.</td>
<td>Impact test results for LT steel castings and forgings wherever applicable.</td>
<td>x</td>
<td>x</td>
<td>Yes</td>
</tr>
<tr>
<td>18.</td>
<td>Installation, operating and maintenance manual (12 sets) including parts lists.</td>
<td>x</td>
<td>x</td>
<td>Yes</td>
</tr>
<tr>
<td>19.</td>
<td>Transparency for each tag no. dimensional drawings.</td>
<td>x</td>
<td>x</td>
<td>Yes</td>
</tr>
<tr>
<td>20.</td>
<td>Quality Assurance Plan</td>
<td>x</td>
<td>Yes(A) (within 2 weeks)</td>
<td>x</td>
</tr>
</tbody>
</table>

(A) for Approval (I) for information.

Sl. no. 1 to 19 shall be forwarded to OWNER as per details outlined in Enquiry / order. Sl. no. 20 shall be mutually finalised with Inspection Authority specified in the order.

Number of sets alongwith bid for approval and as final documentation shall be supplied as stipulated in the purchase order.
STANDARD SPECIFICATION FOR
RUPTURE DISC
CONTENTS

SECTION NUMBER | DESCRIPTION
---|---
1.0 | GENERAL
2.0 | GENERAL REQUIREMENT
3.0 | INSPECTION, FACTORY TESTS AND APPROVAL
4.0 | PACKING
5.0 | IDENTIFICATION AND MARKING
6.0 | SPARES
7.0 | DOCUMENTATION

LIST OF ATTACHMENTS

ATTACHMENT NUMBER | DESCRIPTION | NUMBER OF SHEETS
---|---|---
1.00 GENERAL

1.01 This Engineering specification together with the Instrument specification attached herewith define the technical requirement for the supply of rupture disc its spares, documentation, and testing.

1.02 In the event of any conflict between Engineering specification and Technical specification of the Rupture disc, the latter shall prevail.

2.00 GENERAL REQUIREMENT

2.01 All rupture disc shall be sized in accordance with API RP 520 or ASME codes section I & VIII as specified in the individual specification sheet. In cases, where exponent of the isentropic expansion has not been stated in the data sheets 1.4 shall be used for calculation purpose. Any restriction in the discharge area caused by the disc holder assembly shall be considered in the calculations. Vendor must submit orifice calculations and corresponding selected body sizes for approval.

2.01.1 CONTRACTOR shall provide rupture disc assembly wherever shown in P&ID. The assembly shall consist of:
A) The rupture disc fitted in a pre torqued holder assembly.
B) J bolt for proper installation
C) The Rupture disc experiences vacuum, shall be provided with vacuum support as recommended by manufacturers.

Disc material shall be compatible with the vessel contents and shall be consistent with the bursting requirements. Inconel discs shall be used above 100ºC if compatible with the process fluid.

2.01.2 When rupture disc is used upstream of a pressure relief valve, a pressure gauge, pressure switch and excess flow check valve / safety relief valve as recommended by manufacturers. (Tell-tale assembly) shall be provided on the downstream of the disc to indicate any rupture of the disc. In addition derating capacity factor for the safety valve – rupture disc assembly as recommended by ASME section VIII shall apply. Tell – tale assembly as above must be provided irrespective of P&ID representation. For plugging toxic service pressure gauges shall be diaphragm seal type.

2.01.3 Each rupture disc must be supplied with minimum three number of additional discs. This is in addition to discs required for carrying out burst testing at factory.

2.01.4 The indication of leaky rupture disc (i.e. the disc with a pen hole) or burst rupture disc shall be provided in the main control room.

2.01.5 The bursting tolerance of the rupture disc shall be ±5% of the specified bursting pressure or less. Unless otherwise specified.
2.02 Rupture disc devices shall be supplied as a complete unit i.e. disc holder and the required number of discs. The scope shall also include pre-assembly screws, jack screws, companion flanges, studs, nuts & gasket.

2.03 Flow direction, flange size and rating, burst pressure and temperature shall be marked on the disc holder.

2.04 The type and material of rupture disc shall be selected in accordance with service conditions, like pressure, temp., process media, vacuum or pulsating service.

2.05 Reverse buckling and non-fragmenting discs are preferred.

2.06 Disc holders shall be suitable for mounting between flanges. The design shall prevent wrong installation of the disc.

2.07 Rupture disc used at inlet of safety valves shall have fragmentation free burst. The stamped capacity of safety valves shall be derated by 20%, unless the combined capacity of the rupture disc and safety relief valve is established by the disc manufacturer.

2.08 The space between safety valve and rupture disc shall be vented during normal operation. The disc holder shall be supplied with 4” telltale pressure gauge with SS body, wetted parts, pipe nipple, excess flow valve. The excess flow valve and pressure gauge shall have 1/2” NPT connections.

3.00 INSPECTION, FACTORY TESTS AND APPROVAL

3.01 All instruments and accessories shall be inspected & tested to ascertain that the supply is in accordance with approved specification. The inspection & tests shall not relieve the supplier/ manufacturer from his responsibilities for materials and the performance of the instrument supplied.

Within two weeks of receipt of the Letter Of Intent (LOI) /order, vendor must contact the Inspection Agency specified in the order and finalise with them the Quality Assurance Plan (QAP) for carrying out Inspection and test.

In absence of any Inspection Agency the vendor must submit the Quality Assurance Plan for PDIL/OWNER’s approval. All tests, in such cases, shall be conducted by manufacturer’s quality department and the results of tests shall be forwarded alongwith the supply.

Procedure and extent of tests shall be governed by QAP mutually agreed between the vendor and PDIL/OWNER’s inspection authority.

No instrument / accessory shall be shipped until all the required tests are successfully completed and certified “Cleared for dispatch” by the inspection authority.

4.00 Packing

Each rupture disc and its accessories wherever applicable shall be suitably packed and protected from damage due to transportation, loading and unloading.

The rupture disc alongwith their spares shall be despatched as a single consignment.
5.00 IDENTIFICATION AND MARKING

5.01 Self adhesive tapes or signs are not permissible for permanent marking of any instrument.

5.02 Each rupture disc shall be fitted with a SS tag plate and shall contain the following information:
   - Complete tag no of the assembly as per inst. Data sheet.
   - Manufacturer’s name
   - Disc and holder model and serial no.
   - Inlet and out sizes with ratings
   - Holder and disc material.
   - Burst pressure in kg/cm²g.

Besides the above each instrument shall have a separate circular tag number plate in stainless steel with engraved tag number and range and attached securely to the instrument with a soft stainless wire. The size of letters and figures shall be minimum 4mm and the plate should be 25mm diameter with 1-2 mm thick. Also each instrument shall have corrosion resistance nameplate with 6 mm minimum size black letters on white background and identified with their relevant loop number.

5.03 All spare parts shall be fitted with identification plate having following data clearly printed and easily readable.

   - Spare parts name/model no. as per purchaser’s Instrument specification sheet
   - Serial no.

6.0 SPARES

Spare parts for rupture shall be supplied as per spares list separately enclosed
### 7.0 DOCUMENTATION

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>DESCRIPTION OF DOCUMENT</th>
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<tr>
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<td>Consolidated list of drawing &amp; documents.</td>
<td>Yes</td>
<td>yes (I)</td>
<td>yes</td>
</tr>
<tr>
<td>2.</td>
<td>Catalogue &amp; technical literature of rupture discs and accessories.</td>
<td>Yes</td>
<td>x</td>
<td>yes</td>
</tr>
<tr>
<td>3.</td>
<td>Sizing calculation for rupture disc.</td>
<td>Yes</td>
<td>Yes(A)</td>
<td>Yes</td>
</tr>
<tr>
<td>4.</td>
<td>Deviation if any, from the technical spec. giving justification for the same.</td>
<td>Yes</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>5.</td>
<td>Dimensional and sectional drawing for each rupture disc indicating weight and showing material of construction of each part.</td>
<td>x</td>
<td>Yes(I)</td>
<td>Yes</td>
</tr>
<tr>
<td>6.</td>
<td>Material test certificates / Mill Certificate from independent recognised agency showing chemical analysis, physical analysis, Ferrite content on finished products.</td>
<td>x</td>
<td>x</td>
<td>Yes</td>
</tr>
<tr>
<td>7.</td>
<td>List of routine tests performed on rupture discs</td>
<td>x</td>
<td>x</td>
<td>Yes</td>
</tr>
<tr>
<td>8.</td>
<td>Manuals for installation, operation &amp; maintenance</td>
<td>x</td>
<td>x</td>
<td>Yes</td>
</tr>
<tr>
<td>9.</td>
<td>&quot;As supplied&quot; data sheet signed by qualified engineer</td>
<td>x</td>
<td>x</td>
<td>Yes</td>
</tr>
<tr>
<td>10.</td>
<td>Quality assurance plan</td>
<td>x</td>
<td>yes (A)</td>
<td>x</td>
</tr>
</tbody>
</table>

**NOTES:**

1. (A) for Approval    (I) for information

2. Sl. No. 1 to 9 shall be forwarded to principal as per details outlined in enquiry/order.

3. Sl. No. 10 shall be mutually finalised with Inspection Authority specified in the order.

Number of sets alongwith bid for approval and as final documentation shall be supplied as stipulated in the purchase order.
STANDARD SPECIFICATION

FOR

CLOSED CIRCUIT TELEVISION (CCTV) SYSTEM
Abbreviations:

BIS : Bureau of Indian Standard
CCOE : Chief controller of Explosives
CIF : Common Image Format
CMRI : Central Mining Research Institute
ERTL : Electronics Regional Testing Laboratory
DGMS : Director General of Mine safety
IEC : International Electrotechnical commission
Ip : Internet Protocol
MPEG : Motion Picture Experts Group
PAL : Phase Alteration by Line
TCP : Transmission Control Protocol
UDP : User Datagram Protocol
CCD : Charge Coupled Device
1.0 GENERAL

1.1 Scope
1.1.1 This specification, together with the data sheets attached herewith, covers the requirements for the design, materials, nameplate marking, inspection, testing and shipping of Closed Circuit Television (CCTV) system.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest edition prior to the date of purchaser's enquiry;

ANSI/ASME  
American National Standards Institute/American Society of Mechanical Engineers.

B 1.20.1  Pipe Threads General Purpose (Inch)
B 16.5  Steel Pipe Fittings and Flanged Fittings, NPS 1/2” through NPS 24

EN-I 0204  Inspection Documents For Metallic Products

IEC-60079  Electrical Apparatus for Explosive Gas Atmospheres

IEC- 60529  Degree of Protection Provided by Enclosures (IP Code)

rs- 13947  Specification for Low Voltage Switchgear and Control gear

IS- 2148  Electrical Apparatus for Explosive Gas Atmosphere - Flameproof enclosures 'd'

1.1.3 In the event of any conflict between this standard specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations
b) Data Sheets
c) Standard Specification
d) Codes and Standards

1.1.4 In addition to compliance to purchaser's specification, Vendor's extent of responsibility shall include the following:

a) Purchaser's data sheets indicate the minimum requirements of camera, video encoders, video management system, video recorders etc., however, this does not absolve the vendor of the responsibility for proper selection with respect to the following:

i) Selection of lens focal length, camera, encoding techniques, selection of hardware and appropriate software for video management, selection of video recorder and its sizing to meet the storage requirements mentioned in the datasheets, accessories etc for proper monitoring and control.

ii) Selection of equipment suitable for the environmental conditions.

b) Carryout complete application engineering so as to achieve the desired objectives with the stated performance requirements.

c) Provide all hardware and software, as necessary, to meet functional requirements specified in the purchaser's specification.
1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition.

1.2.2 Vendor's technical offer shall include the following:

   a) Compliance to the specifications.

   b) Detailed specification sheet for each item providing all the details regarding make and model, type, construction, Maximum and minimum viewable distance, Maximum tilt or pan angle possible, Pan and tilt speed, Allowable Voltage and frequency variations, Interconnecting cable and transceiver module specifications, utility requirement, Network Bandwidth requirements and calculations to support the same considering bus loading as' 50% maximum, Hardware, software and licensing requirements, Storage calculations for video recorders.

   c) Detailed dimensional and sectional drawings including mounting details for all the units offered. All dimensions shall be in millimeters.

   d) Block-diagram showing all units with model numbers.

   e) Interconnection wiring diagram between the various components of CCTV system, including location of each item. The diagram shall show the size of cable and brief specification of the cable.

   f) Proven references for the offered model of CCTV system in line with clause 1.2.3 of this specification.

   g) A copy of approval from local statutory authority, as applicable, such as Petroleum and Explosives Safety Organization (PESO), Chief Controller of Explosives CCOE), Nagpur or Director General of Mines Safety (DGMS) in India, for the electronic instruments installed in electrically hazardous area along with:

      i) Test certificate from recognised test house like CIMFR/ERTL etc. for flameproof enclosure, as specified in the data sheet, as per relevant standard for all Indian manufactured equipments or for items requiring DGMS approval.

      ii) Certificate of conformity from agencies like LCIE, Baseefa, PTB, CSA, FM, UL, CE etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

   h) Power consumption for the complete CCTV system including accessories.

   i) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason, they must include a list of deviations clausewise, summing up all the deviations from the purchaser's data sheets and other technical specifications along with the technical reasons for each of these deviations.
j) Catalogues giving detailed technical specifications model decoding details and other information related to hardware and software for the items covered in the bid.

1.2.3 The integrated CCTV system comprising of Cameras, encoders, video management system, video recorder etc, as offered, shall be field. proven and should have been operating satisfactorily individually for a period of minimum 02 years on the bid due date in the conditions similar to those as specified in the purchaser's data sheets. Items with proto-type design or items not meeting proveness criteria specified above shall not be offered.

1.2.4 Vendor's quotation, catalogues, drawings, installation, operation and maintenance manuals shall be in English language.

1.2.5 Vendor shall also quote for the following:
   a) All associated accessories and cables.
   b) Two years operational and maintenance spares for all items including their accessories as per vendor's recommendation which shall include the following as a minimum:
      i) Each type of electronic module
      ii) Fuses
   h) Any special tool or test equipment needed for calibration and maintenance work.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of reproducible, prints and soft copies shall be dispatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual etc. shall be submitted by vendor after placement of purchase order shall include the following as a minimum:
   a) Specification sheet for each camera and its accessories.
   b) Certified drawings for the CCTV system which shall provide the following information:
      i) Overall dimensions in millimetres
      ii) Detailed interconnection diagram identifying each component with terminal number, cable type, cable size and cable entry details. The interface details shall be clearly identified in the drawing
      iii) Grounding detail of each item
      iv) Power supply distribution details
      v) Clearance space required for maintenance work
      vi) Weight of camera and other accessories
c) Configuration data.
d) Power consumption.
e) Installation procedure of camera and other accessories.
f) Maintenance procedure including replacement of its parts/ internals.
g) Copy of type test certificates.
h) Copy of the test certificates for all the tests indicated in clause 4.0 of this specification.

2.0 DESIGN AND CONSTRUCTION

2.1 The Closed Circuit Television (CCTV) system shall consist of the following units as a minimum:

a) Camera Unit.
b) Composite Video Baluns for Video Transmission
c) Video encoders
d) Video management, Video analysis system along with LCD monitors
e) Video Recorder
f) CCTV System cabinet
g) Power supply distribution board
h) Cables, cable glands, connectors and other accessories
i) Network switches

2.1.1 CAMERA UNIT

Camera unit shall consist of Video Camera, camera unit enclosure, remote controlled pan and tilt unit, remote controlled washer and wiper assembly, sun shield - and thermostatically controlled heaters, receiver units, junction boxes etc.

2.1.1.1 Video Camera

a) Unless otherwise specified, the video camera shall be colour type comprising of y,, or 113°cmos sensor with HD resolution of 540 TVLs (TVL: TV lines) as a minimum.
b) The camera shall have Automatic Gain Control (AGC) facility with gain adjustment of typically up to 18dBA. The video amplifier shall ensure a signal to noise ratio of 50.
c) The camera shall be able to operate satisfactorily under varied light intensity levels. The light sensitivity of the CCTV camera shall be 2.5 lux and shall be able to view objects in illumination level of 45 lux at the distance of 50 m as a minimum.

d) Automatic lens iris control facility shall also be provided as per' the background light levels.

e) The focal length of the camera shall be based on the distance of the objects from the camera. The lens adjustment for focus control and zoom control shall be motorized and remote controllable.

f) The camera shall have feature of backlight compensation.

2.1.1.2 Camera unit enclosure

Camera unit enclosures in safe areas shall be weather proof to IP-65 as per IS-13947. Camera unit enclosures in hazardous areas shall meet the following requirements, as a minimum:

Weather-proof : IP-65 as per IS-13947

Camera unit enclosure shall be suitable for the area classification indicated in the datasheets.

2.1.1.3 Pan and Tilt Unit

The pan and tilt arrangement shall be able to adjust camera within an angle of 0° to 335° horizontally (i.e. pan range) and a minimum of 180° (±900) vertical (i.e. Tilt range). The movement of the device shall be smooth. Pan speed shall be 6 degrees /sec and tilt speed shall be 3 degree/second as a minimum. Pan and tilt action shall be operable from video management system in control room. Pan and tilt unit shall be suitable for area classification as indicated in the datasheets. Pan and tilt units shall also be weatherproof to IP-65 as per IS13947.

2.1.1.4 Wiper and Washer

Whenever camera is for outdoor installation or the application necessitates. the glass window shall be provided with a wiper and washer unit. The washer unit shall comprise of washer tank, motor & pump and associated tubing. The washer tank shall be placed in an FRP enclosure near the camera and shall be easily accessible. The tank shall have a water inlet connection, a valve along with ball float actuator, a water outlet connection, necessary tubing & connectors between the water outlet connection, water pump, and nozzle at the camera. The rising water level in the tank shall raise the lever which will close the valve. The pump shall either be located in the explosion proof housing of the camera or placed inside the FRP enclosure of the washer tank. Whenever the pump is placed in the FRP enclosure, it's motor shall be explosion proof certified for the area classification. Vendor shall indicate the media to be used for actual washing with requirements like flow, pressure etc. Whenever specified, the washer tank shall have a capacity of 10 litres as a minimum and the minimum flow rate of the pump shall be 0.5 litres per minute.

2.1.1.5 Space Heater

For outdoor applications and where there is a possibility of condensation on the glass window, the camera unit shall be provided with a thermostatically controlled anti-condensation heater.
2.1.1.6 Junction Box

The junction boxes for housing the accessories shall be suitable for outdoor installation with minimum IP-65 weatherproof protection and shall be certified for the specified area classification as per datasheets.

2.1.1.7 Camera Mounting

Cameras shall be provided with suitable mounting accessories for mounting on structures, roofs, poles as indicated in the datasheets. Whenever specified, the height of the support poles shall be as per the datasheets. The pole shall have ladder for camera maintenance.

2.1.2 VIDEO ENCODER

a) The video encoder shall digitize and compress the video signal using MPEG-4 & MJPEG compression technique. The operator shall have the option of changing the frame rate from 1 to 25 frame per second (fps)/camera and also change the resolution to CIF,2CIF and 4CIF (PAL).

b) The video encoder shall be capable of TCP/UDP, unicast and Multicast transmission of live video. If connected over an IP network, then each video encoder shall be IP addressable and shall be able to connect to networking devices such as switches/ routers. Encoder shall be single/ multi channel as specified in the datasheets. Multi channel encoder shall have 4 channels maximum.

c) The video encoder shall be capable of receiving camera control commands from video management system and relay them to cameras on RS485.

d) The encoder shall be capable of detecting the loss of video signal from the camera video output.

e) Encoder shall have motion detection.

f) The encoder shall be able to send alarm signals (e.g., on motion detection or loss of video signal) over the network to the respective video management system. The video management system at the control room shall receive the alarm signals over the network and shall drive outputs such as an audible alert or a visual indication on a monitor to alert an operator.

g) It shall be possible to upgrade the video encoder software remotely.

2.1.3 VIDEO MANAGEMENT SYSTEM

2.1.3.1 The system shall support the virtual matrix capability (i.e., software based matrix) to allow the operator to assign any camera to any local or remote monitor on the network. Also it shall be possible to Control and monitor any camera on the network.

2.1.3.2 The video management system shall be able to permit online selection of:
a) Camera Units

b) Monitors

c) No. of views on one monitor

d) Recording Commands

e) Pan-tile Control

f) Sequential Switching of image on monitors

g) Focus, wiper, wash and zoom operating for each camera unit.

2.1.3.3 The monitors shall be 26” colour LCD monitors with necessary controls like colour brightness, contrast adjustment and monitor ON/OFF control. These functions shall be possible from the monitor front.

2.1.3.4 The camera views on the monitor shall be populated based on the operator request. The operator shall be able to view 1/4/9/16 views per monitor. The operator shall be able to enlarge the views.

2.1.3.5 The operator shall be able to view cameras through simple drag and drop commands.

2.1.3.6 The system shall be equipped with the web based client software to allow users to view the cameras on the Microsoft explorer browser from any PC on the network, provided if they are given the permission and password.

2.1.3.7 The user interface shall present the operator with a camera tree that shall show the list of all the cameras and camera sequences that are available to the operator. The Vendor shall present the hierarchy of the camera tree together with the grouping of cameras and the way in which the user/ operator shall interact with it.

2.1.3.8 The NVMS user interface shall have a map to allow viewing the graphical representation of the area together with allowing the operator to place camera icons on the map. The Vendor shall present the full features and operations of the map and shall present the way in which the user/ operator shall interact with the map.

2.1.3.9 The operator shall be able to perform pan/ tilt! zoom/ washer and wiper unit control for PTZ cameras.

2.1.3.10 The operator shall be able to enable/ disable Motion detection for cameras.

2.1.3.11 The operator shall be able to write macros/scripts for the cameras to do the following as a minimum:

(i) To define the sequence of cameras to be viewed on a given monitor

(ii) To define the period and start/ stop time for viewing a camera on a monitor
2.1.3.12 The viewing and control of cameras shall be controlled by use of passwords. Two levels of password shall be provided:

   a) The operator level in which the operator shall be able to perform PTZ controls, viewing, recording and playback.

   b) The supervisor level in which the supervisor shall be able to make configuration changes in addition to the PTZ controls, viewing, recording and playback.

2.1.3.13 VIDEO RECORDER

   a) Whenever specified the system shall also supplied with video recorder to record video images automatically or on manual demand. The recorder shall meet the following requirements as a minimum.

   b) The video recorder shall have disk space to store on-line video storage for duration as specified in the datasheets and access to high capacity archiving mechanisms for removal of stored video to off-line storage media.

   c) The vendor shall size the video recorder hard disc space based on the number of cameras, number of days (minimum 30 days) for which the recording has been done, the resolution of recording and the number of frames per second to be recorded, as indicated in the datasheets. Vendor shall submit calculations/ equations for storage requirements. Use of software without supporting calculations shall not be acceptable.

   d) The system shall mark the events with time and date stamping during monitoring and recording. The system shall allow the operator to view stored information with respect to time and date of recording with scan and search of the marked events/ timing.

   e) The operator shall be able to playback the recorded events in slow and fast motion with variable speed.

   f) It shall be possible for the operator to schedule recordings for each individual camera taking place in the future. The operator shall be able to configure the Start and Stop time for the scheduled recording.
g) The operator shall be able to export previously stored video to DVD or latest storage option as specified in the datasheets.

h) The exported video shall be able to retrieve archived video from DVD or the latest storage option as specified in the datasheets.

i) Captured images or videos shall be easily distributed to any remote locations through the LAN/WAN environment, if required. The operator shall be able to export previously stored video from a recorder to any other network storage devices including a network drive. An exported file must be in MPEG-4/ MJPEG format and, as such, should be readable using any MPEG-4/MJPEG compliant decoding software.

j) Each video recorder shall be of 19” rack mountable type.

k) Video recorder shall support RAID 0 +1 as a minimum.

2.1.3.14 VIDEO ANALYSIS

a) System shall generate alarm on motion detection in areas where no motion is expected.

b) System shall generate alarm on no motion detection in areas where motion is expected.

c) System shall generate alarm on flare flame failure.

d) System shall generate alarm in case fire is detected.

e) System shall generate alarm when toxic cloud is observed.

2.1.4 ALARMS & EVENTS

a) The operator in the control room shall be able to get an indication of the faults occurring in any of the devices connected over the network. This includes faults occurring in the cameras, video encoders, computers, and video recorders. Faults occurring in each of these devices shall generate an alarm in the operator console.

b) The operator shall be able to view the chronology of events by device, date, time description.

c) The system shall support logging of events for reviewing and analysis in the future.

d) Upon detecting a fault, the system shall be able to automatically send an E-mail alert.
2.1.5 CONFIGURATION

The following facilities shall be provided for configuration of the CCTV system as a minimum:

a) Assign an ID or name to each camera.
b) Add/delete cameras.
c) Change the camera details (e.g. Camera location, Camera ID, Camera number, etc)
d) Configure the camera encoding parameters in terms of number of frames per second.
e) Configure the camera encoding resolution in terms of setting it to CIF, 2CIF, or 4CIF.
f) Creation of schedules for recordings.
g) Configure recording either on demand, continuous recording or based on motion detection.
h) Add/ delete monitors to the system.
i) Add/ delete computers to the system.
j) Creation of a camera group, view a camera group, view a camera sequence, and view a multiple view screen.
k) For an IP based system, assign IP addresses to video encoders, computers of video management system, video recorders, video wall controllers as applicable.
l) Program external outputs based on certain events.

2.1.6 INTERFACING WITH DCS

Wherever specified, interfacing with DCS shall be done to allow DCS operators to view live video along with DCS graphics on the DCS operator consoles. Hardware required for the same shall be provided by vendor. Software required in video management system and DCS shall be provided by vendor.

2.1.7 CCTV CABINETS

2.1.8.1 The CCTV cabinet(s) shall house the following components: (i) Computer(s) (ii) video encoder(s), (iii) video recorder(s), (iv) control unit (v) network switches (vi) Transceiver modules, if any (vii) indoor fibre patch panel, if any (viii) VGA boosters, if any(ix) Line drivers, if any (x) Miniature circuit breakers etc. as applicable.

2.1.8.2 The cabinet(s) shall be fitted with lockable doors and shall have front and rear access. All system cabinets shall be completely wired.
2.1.8.3 The cabinet shall be free standing, enclosed type and shall be designed for bottom cable entry. Cabinet structure shall be rigid and shall be provided with removable lifting lugs to permit lifting of the cabinets.

2.1.8.4 Cabinets shall be fabricated from cold rolled sheet steel of minimum 2 mm thickness suitably reinforced to prevent warping and buckling. Doors shall be fabricated from cold rolled steel sheet of minimum of 1.6 mm thickness. Cabinets shall be thoroughly de-burred and all sharp edges shall be grounded smoothened after fabrication.

2.1.8.5 Each cabinet shall be of maximum 2100 mm height and 1200 mm width. Construction shall be modular preferably to accommodate 19” standard electrical racks. Maximum swing out for Pivot card racks, doors and drawers shall be limited to 600 mm. Doors of the cabinet shall be equipped with lockable handles and concealed hinges with pull-pins for each door removal.

2.1.8.6 In order to effectively remove dissipated heat from the cabinets, vent louvers backed by wire-ply screen shall be provided on the cabinet doors. Ventilation fans shall be provided in each cabinet along with fan failure alarm contact.

2.1.8.7 Fluorescent lamps shall be provided in each cabinet for each cabinet for internal illumination along with door operated micro switches. All lighting shall be on 230v 50Hz normal power supply.

2.1.8.8 All wiring within the cabinet shall be neatly laid and shall be accessible. Clamping rails shall be provided for incoming cables to present excessive stress on the individual terminals. All metal parts of the cabinet including doors shall be electrically continuous and shall be provided with common grounding lug.

2.1.8.9 The color of the CCTV cabinets shall be matched with the existing cabinets at control room.

2.1.8.10 Cable glands shall be provided for cable entry into the CCTV cabinet. Spare cable entries shall be plugged.

2.1.8 OPTICAL FIBER CABLE

The Optical Fiber Cable (OFC) used for the CCTV system shall conform to the following specification as a minimum:

a) The OFC shall be CSTA (corrugated steel tape armored, electrolytically chrome plated low carbon steel) armored cable.

b) The OFC shall have FRP strength member, loose tubes for single mode optical fibers filled with moisture resistant jelly, moisture barrier of polymer coated Aluminum tape or water swellable tape, inner sheath of HOPE and outer sheath of PVC.

c) Optical fibers shall be single mode fibers compliant to ITV-T G 652 and fibers colours shall correspond to IEC 793-2 and 304. Optical fibers shall be coated with UV cured double acrylic resin. It should not have any reaction with cladding or core material.
coating should provide maximum resistance to micro-bending & abrasion and ensure mechanical & optical strength. The coating shall be easily stripped with mechanical tools.

d) The number of fibers in the OFC shall be decided depending upon the requirement with 8 fibers as a minimum.

e) The cabled fiber attenuation shall be -S 0.37 dB/km for 1310 nm wavelength range and 0.22 dB/km for 1550 nm wavelength range.

f) The tensile performance shall be as per IEC-794-IEC and with tensile load of 9.81 W Newton with attenuation change -S 0.05 dB/km at 1310 nm. W is weight of OFC/km.

2.1.9 NETWORK SWITCH

The network switch used for the CCTV system shall conform to the following specification as a minimum:

The network Switch shall be configured to provide communication paths and provide the facility for adaptive packet and message routing through any available communication link. The network Switch shall provide the facility of multiple protocol router and bridge that provides high bandwidth connections into backbone networks for remote sites.

The hardware design shall be based on distributed processing architecture with packets forwarding to be performed on the network interface modules. It shall be based on the modular design and architecture and shall allow new network interface cards to be added in the racks without powering down the unit and ensuring no disruption of service to the network users.

The network Switch shall support both intra-area and inter-area routing for transporting messages between nodes and shall support the network routing! bridging services for OSI, TCP/IP, X.25, LAT and other industry standard wide area networks/protocols. The network switch shall be adaptive 10/100/1000 Mbps interface port, supporting pass through! Crossover adaptation of port. The network switch shall be provided with optical fiber module interface suitable for long distance transmission.

2.1.10 POWER SUPPLY

2.1.10.1 The system shall operate on 110 VAC/230VAC (as specified in the datasheets) with the following specifications:

Voltage variation 

± 10%

Frequency 

50 Hz± 3 Hz

Any other power supply required shall be derived from this power supply by the vendor.

2.1.10.2 Power Supply distribution for all items related to closed circuit television system shall be carried out from the system cabinet itself. Vendor shall supply any hardware required for conversion/distribution. Power supply for each item shall be provided with a separate switch and fuse for isolation and protection of the system.
2.1.10.3 The CCTV camera unit shall be capable of withstanding plant vibration level of 2.1 G (within the frequency range of 5 Hz to 200 Hz) and sudden shocks of level 5 G (with frequency of 2 Hz). Any vibration pads required to meet this requirement shall be in vendor's scope of supply.

2.1.10.4 The CCTV system shall have the capability for future expansion to add cameras and additional storage in video recorders.

2.1.10.5 All cable glands, as required, for camera enclosure, pan/tilt unit, junction boxes, CCTV cabinet etc. shall be Nickel plated brass, dual compression type, suitable for area classification specified in datasheets.

3.0 NAMEPLATE

3.1 Each camera shall have a SS label name plate attached firmly to it at a visible place furnishing the following information:

a) Manufacturer's model no. and serial no.

b) Manufacturer's name / trademark.

c) Type and Resolution of Camera

d) Lens Focus Length

e) Pan and Tilt Range

f) Type of explosion protection and certificate number

g) Power Requirement.

3.2 Each item of Close Circuit Television and its accessory shall have SS labels attached firmly to it at a visible place, furnishing the following information:

a) Manufacturer's model no. and serial no.

b) Manufacturer's name / trademark.

c) Type of explosion protection and certificate number

d) Power Requirement.

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect the system at vendor's works. Vendor shall provide facilities like competent manpower, equipment and utilities required for the purpose to Purchaser's representative for inspection. Vendor shall test and demonstrate integrity of the system hardware and software. No material or equipment shall be transported until all required tests are successfully completed and certified 'Ready for Shipment' by the Owner / Consultant.
4.2 The Purchaser reserves the right to get involved and satisfy himself at each and every stage of project execution. The purchaser shall be free to request any specific test considered necessary by him although not listed specifically. The cost of performing all tests shall be borne by the vendor.

4.3 Vendor shall submit the following test certificates and test reports for purchaser's review:

   a) Dimensional verification certificate
   b) Manufacturer's test reports as per Type 3.1 of EN 10204
   c) Minimum light intensity testing
   d) Power supply variation check
   e) Certificate from Statutory authority for flame proof and weather proof enclosure, as applicable

4.4 Witness Inspection

4.4.1 All items shall be offered for pre-dispatch inspection for following, as a minimum, unless otherwise specified:

   a) Physical dimensional verification and workmanship.
   b) Bill of material check
   c) Effect of variations in power supply, voltage and frequency
   d) Performance testing and verification of integrated CCTV system.
   e) Review of all certificates and test reports.

4.4.2 In case, the witness is waived off by the owner / Consultant, the test report of test carried out by vendor as indicated shall be forwarded by vendor for review. The equipment shall be dispatched only after it is cleared by owner / Consultant for dispatch.

5.0 SHIPPING

5.1 All threaded openings and cable entries shall be suitably protected to prevent entry of foreign material.

5.2 Any glass item shall be protected with foam sheet to protect against damage during transportation.

5.3 Each panel and accessory shall be suitably packed and protected from damage due to transportation, unloading and loading.
5.4 Each component part requiring identification for proper assembly at site shall be piecewise marked.

6.0 REJECTION

6.1 Vendor shall submit their offer in detail, as per clause 1.2 of the specification and shall attach these documents, which are specifically indicated in the material requisition. Vendor shall make offer w.r.t every clause of this specification.

6.2 Any offer not confirming to the above requirements shall be summarily rejected.
FIRE ALARM SYSTEM REQUIREMENTS
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1.0 SCOPE - FIRE ALARM SYSTEM

1.1 LSTK contractor shall provide the Fire Detection and Alarm System which shall be an independent system comprising of individual break glass type manual call points, automatic sensors e.g. smoke and heat detectors, main panel, repeater panel, hooter, battery, battery charger and any other hardware. Contractor has to provide the provision of interface with Centralised Fire Alarm panel and if required by Owner then do the hook up job with centralised FA system.

1.2 Fire alarm system shall be provided in all the enclosed areas such as substation, control room, cabins and wherever flammable equipments are being placed.

1.3 Fire protection for substations shall be provided to comply with requirements of Indian Standard/NFPA. Substations shall be provided with smoke detectors and fire alarm system as per relevant Indian Standard

1.4 The system shall be designed to provide audio-visual indication at the main panel to be located in sub-station and repeater panels shall be provided in fire station.

1.5 The manual call points shall be provided at strategic locations with access of 60 M along all exit routes and roads.

1.6 Electrical sirens shall be provided to cover entire plant area. Hooters and exit lights shall be provided at required locations in the buildings.

1.7 Panel design and component selection shall be done for future extension upto 10% of specified zones or one zone, whichever is maximum in each panel. The design of common facility and hardware shall be provided for required future extension of zones.

1.8 The fire detection system shall be interfaced with fire suppression system, wherever specified.

1.9 Supply, installation, testing and commissioning of above mentioned components/equipment for plant area, substation & control room shall be by the LSTK contractor along with necessary supply and laying of required signals cables.

1.10 The required nos. of MCPs and detectors in substation & control room shall be calculated as per IS norms and contractor shall get approval from client during detailed engineering stage.

1.11 Any other specifications refer TS-0821 & TS-0822.
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1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture and supply of Flame Retardant type PVC sheathed cables for use in plant communication and fire alarm systems and Jelly filled telecommunication cables.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of the latest revision of the following standards issued by BIS and DOT, unless otherwise specified:

2.1.1 BIS standards:

- IS-694: PVC insulated cables for working voltages up to and including 1100V.
- IS-1554 (Part-I): PVC insulated (heavy duty) electric cables-(Part-I for working voltages up to and including 1100V).
- IS-5831: PVC insulation and sheath of electric cable.
- IS-8130: Conductors for insulated cables and flexible cords.
- IS-9938: Recommended Colours for PVC insulation for LF wires and cables.
- IS-10418: Drums for electric cables.
- IS-12444: Continuously cast and rolled electrolytic copper wire rods for electrical conductors.

2.2 DOT Standards:

- GRJWIR-06/03: Specification for cable - switchboard (Screened and Unscreened) Generic Requirements.
- G/CUG-O1/02: Specification for solid polythene insulated fully filled, Polythene sheathed underground telecom cables.

2.3 In case of imported cables, standards of the country of origin shall be applicable, if these standards are equivalent to or stringent than the applicable Indian standards.
2.4 The cables shall also conform to the provisions of the Indian Electricity rules and other statutory regulations currently in force in the country.

2.5 In case Indian standards are not available for any material, standards issued by IEC / BS / VDE / IEEE / NEMA or equivalent agency shall be applicable.

2.6 In case of any contradiction between various referred standards/ specifications/ datasheets and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- This specification.
- Codes and standards.

3.0 SITE CONDITIONS

Cables shall be suitable for installation in following conditions:

i. Above ground in open-air locations (trays / ducts) in tropical, humid and corrosive atmosphere prevalent in refineries/petrochemical plants with severe weathering and exposure to solar radiation.

ii. Directly buried in underground trenches, conduits with uncontrolled back-fill and possibility of flooding by water and chemicals.

iii. Unless otherwise specified, the design ambient air temperature of 45° C / ground temperature of 30° C.

4.0 TECHNICAL REQUIREMENTS - NON JELLY FILLED CABLES

4.1 Conductors

4.1.1 The size of conductor shall be as per job requirement.

4.1.2 The conductors shall consist of annealed, high conductivity solid copper wire, smoothly drawn, circular in cross-section, uniform in quality, free from defects and uniformly coated with pure tin and shall conform to Cl. 3.0 of DOT specification GR/WIR-06/03.

4.2 Insulation

4.2.1 The core insulation shall be with PVC compound applied over the conductor by extrusion.

4.2.2 PVC insulation, when used shall meet the following requirements:

<table>
<thead>
<tr>
<th>Conductor (Area)</th>
<th>Diameter</th>
<th>Type of Insulation</th>
<th>Thickness of Insulation</th>
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<tr>
<td>Upto 0.63 mm (0.3mm²)</td>
<td>Type-2 of Table-3 as per IS-13176</td>
<td>As per Table-1 of DOT Specs. GR/WIR-09/02</td>
<td></td>
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<tr>
<td>Above 0.63mm (Above 3.0 MM²)</td>
<td>Type-A as per IS-5831</td>
<td>Table-2 as per IS-1554 (Part-I)</td>
<td></td>
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</table>
4.2.3 The colours used for insulation shall conform as nearly as practicable to the standard colours as per 18-9938. The wire insulation shall have colours in accordance with Table-2 of DOT specification GR/WIR-06/03. The applied colour shall neither have deleterious effect on the electrical, mechanical or ageing properties of basic insulation nor shall get damaged by any friction etc.

4.2.4 For single pair cables, the colour shall be incorporated in the insulation.

4.2.5 For multi pair cables, cores shall have uniform pattern of continuous spiral (Pitch not exceeding 25mm) to facilitate easy identification. This may be done by the application of one or more coloured strips on a base colour or by direct extrusion.

4.2.6 Alternately, colouring may consist of concentric coloured rings or dots or dashes on the base colour. The coloured rings, dots or dashes shall have a width of not less than 1.0mm and shall be repeated along the length of the insulation at an interval not less than 15mm and not more than 25mm.

4.2.7 The dots or dashes shall be applied on diametrically opposite sides of the insulation, so that all colours are visible when the insulation is viewed from any side.

4.3 Twisting

The two insulated conductors of a pair shall be uniformly twisted with a suitable right hand lay, which shall not exceed 80mm.

4.4 Core Formation

The core formation shall conform to C1.6.0 of DOT specification no. GR/WIR-06/03.

4.5 Screen

4.5.1 Unless otherwise specified the cables used for fire alarm and detection shall be provided with overall screen. The screen shall be of aluminium tape with minimum thickness of 0.04mm. The overlap shall be minimum 3mm for cables up to 50 pair & minimum 6mm for cables above 50 Pair. The screen shall be backed by an outer protective layer of 0.13mm PVC tape or other non hygroscopic material lapped applied longitudinally or helically with overlap.

4.5.2 The cables shall be provided with a drain wire. Drain wire shall have a minimum cross-section of 0.5mm², shall be composed of multistrand bare tinned annealed copper conductor. The drain wire shall be in continuous contact with the aluminium side of the overall screen. The drain wire resistance including screen shall not exceed 30 ohm/km.

4.6 Ripcord

A non-metallic ripcord of suitable quality shall be laid longitudinally under the inner sheath & screen. The ripcord when pulled shall cut through the sheath and strip the core.

4.7 Inner Sheath
4.7.1 An extruded inner sheath of type ST1 PVC, as per IS-5831, with minimum thickness as per Table-4 of IS-1554 (Part-1) shall be applied over the laid up core, by extrusion to fit closely on it.

4.7.2 The inner sheath shall be as circular as possible. It shall be possible to remove the inner sheath without damage to the insulation.

4.7.3 When one or more layers of non-hygrosopic tape is helically applied over the laid up cores, as a binder, the thickness of such tape(s) shall not be construed as a part of the inner sheath.

4.8 Armour

4.8.1 The cables shall be provided with armouring, made of hot dip galvanised steel wire /strip over the inner sheath.

4.8.2 The armour shall be by means of 104mm thick round wires for cables with under armour diameter upto 13mm. For cables with an under armour diameter above 13mm, the armour shall either be of steel strip or round wire with thickness as per IS-1554 (Part-1).

4.9 Outer Sheath

4.9.1 The cables shall be provided with an extruded PVC sheath for external protection. The PVC shall be type ST1 PVC, as per IS-5831.

4.9.2 The other sheath shall be with oxygen index 29 at 27±2°C and possess flame retardant properties meeting the requirements of IS 10810 Part-62 category - AF. In addition, suitable chemicals shall be added to the PVC compound of the outer sheath to protect the cable against rodent and termite attack.

4.9.3 The thickness of outer sheath shall be as per IS-1554 (Part 1).

4.9.4 The outer sheath shall fit tightly on the armour and shall be applied in such a manner that no undue residual strain is left in the material.

4.9.5 The outer sheath shall be grey in colour except for cables to be used for fire alarm system where it shall be red.

4.9.6 Sequential marking of the length of the cable, in meters, shall be provided on the outer sheath at every one meter. The marking shall be legible and indelible by suitable method.

4.9.7 The overall diameter of the cables shall be strictly as per the values declared in the technical information furnished along with the bids, subject to a maximum tolerance of ±2 mm.

4.10 Cable Capacitance

4.10.1 The core to core capacitance of the cables shall not exceed 100nF/Km at 1KHz.

4.10.2 The core to screen capacitance for the screened cables shall not exceed 250nF/Km at 1KHz.
5.0  TECHNICAL REQUIREMENTS FOR JELLY FILLED CABLES

5.1  Jelly filled telecom cables shall in general conform to the requirements of DOT specification G/CUG-01/02, unless otherwise specified in this specification.

5.2  Conductors

5.2.1 The conductors shall consist of annealed, high conductivity solid copper wire, smoothly drawn, circular in cross-section, uniform in quality, free from defects and uniformly coated with pure tin and shall conform to cl. 3.0 of DOT specification G/CUG-01/02.

5.3  Insulation

5.3.1 Each conductor shall be insulated with insulating grade PE conforming to C1.4.0 of DOT specification G/CUG-01/02.

5.4  Twisting

The two insulated conductors of a pair shall be uniformly twisted with a suitable right hand lay, which shall not exceed 150mm.

5.5  Core Formation

The core formation shall conform to C1.6.0 of DOT specification G/CUG-01/02.

5.6  Filling Compound

5.6.1 The cable shall be filled with a suitable stable water resistant compound, which shall be compatible with the insulation, binders and tapes used in the cable.

5.6.2 It shall be homogeneous and uniformly mixed material containing an anti-oxidant.

5.6.3 The compound shall not obscure the identification of the colour of the insulation of the conductors.

5.6.4 It shall not contain dirt, metallic particles or other foreign matter.

5.6.5 The compound shall be readily removable from the insulated conductors by wiping.

5.6.6 It shall be free from any unpleasant odour and shall have no toxic or dermatic hazards.

5.6.7 The flash point of the compound shall not be less than 200°C.

5.6.8 The volume Resistivity measured at 100°C shall not be less than 1010 ohm- ern.

5.6.9 The permittivity at 1 MHz tested as per ASTM 0-924 shall not be greater than 2.3 at 20°C.

5.7  Core Wrapping

At least one closed helical or longitudinal application of a non-hygroscopic and non-wicking polyester tape or tape of any other suitable material shall be provided over the cable core.

5.8  Screen
The cables shall be provided with overall screen. The screen shall be of aluminium tape with minimum thickness of 0.2mm. The overlap shall be minimum 3mm for cables having maximum diameter over inner sheath < 30mm & minimum 6mm for cables having maximum diameter over inner sheath ~ 30mm. The screen shall be coated with 0.05 mm nominal thickness polythene/copolymer on both sides. The thickness of the composite tape shall be 0.3mm±15%.

The aluminium tape shall be electrically continuous throughout the length of the cable.

5.9 Inner Sheath

5.9.1 The inner sheath shall be as circular as possible and free from pinholes and other defects. It shall be possible to remove the inner sheath without damage to the insulation.

5.9.2 The inner sheath shall be of polythene conforming to type 03C or H03C of BS 6234 and shall contain a suitable antioxidant system. The material shall be virgin as per ASTM 0-883 and meet the following requirements.

Density 0.910 to 0.940 g/10 minutes (190 °C, 2160 g load)

5.9.3 The thickness of inner sheath shall conform to Table - 6 of DOT specification no. G/CUG01/02.

5.9.4 The maximum diameter over inner sheath shall conform to Table - 7 of DOT specification no. G/CUG-0 1/02.

5.10 Armour

5.10.1 The cables shall be provided with bedding and armour over the inner sheath.

5.10.2 The bedding shall consist of two close helical lappings of polythene or polypropylene tape. Each tape shall be applied with a minimum of 5% overlap.

5.10.3 The armour shall be made of hot dip galvanised steel tape of thickness as per Table - 8 of DOT specification G/CUG-01/02.

5.11 Outer Sheath

5.11.1 The external protection shall consist of a polythene sheath conforming to the material specification defined in Clause 5.9 above.

5.11.2 The thickness of outer sheath shall conform to Table - 9 of DOT specification G/CUG-01/02.

5.11.3 The outer sheath shall be as circular as possible and free from pinholes and other defects. It shall be possible to remove the inner sheath without damage to the insulation.

5.11.4 The outer sheath shall be grey / black in colour except for cables to be used for fire alarm system where it shall be red.
5.11.5 The maximum diameter over outer sheath shall conform to Table - 7 of DOT specification G/CUG-01/02.

5.12 Cable Capacitance

The average mutual capacitance of the pairs measured at 800 to 1000Hz shall be $52 \pm 3$ nF/km.

However, the mutual capacitance of individual pairs shall be within the limits of $52 \pm 4.5$ nF/km.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 The cables shall be tested and examined at the manufacturer's works. All the materials employed in the manufacture of the cable shall be subjected to examination, testing and approval by PDIL/Owner. Manufacturer shall furnish all necessary information concerning the supply to PDIL/Owner's inspectors. The inspector shall have free access to the manufacturer's works for the purpose of inspecting the process of manufacture in all its stages and he will have the power to reject any material, which appears to be of unsuitable description or of unsatisfactory quality.

6.2 The following acceptance tests shall be conducted on the completed jelly filled cables as per the test procedures given in DOT specification G/CUG-01/02 and this specification:

i. Measurement of diameter of conductor, over inner sheath & over outer sheath.

ii. Measurement of Thickness of insulation, inner sheath, screen, armour & outer sheath.


vi. Colour coding.

vii. Conductor continuity test.

viii. Mutual Capacitance test.

ix. Capacitance Unbalance test.

x. Cross talk test.

xi. Attenuation test.

xii. Insulation resistance test.

xiii. Dielectric strength test.

xiv. Drip test.
xv. Armour Galvanisation Test.

xvi. Conductor Annealing Test.

xvii. Measurement of drum length.

6.3 The following tests shall be conducted on the completed non jelly filled cables as per the test procedures given in DOT specification GR/WIR-06/03 and this specification:

6.3.1 **Acceptance tests:**

i. Measurement of diameter of conductor, over inner sheath & over outer sheath.

ii. Measurement of Thickness of insulation, inner sheath, screen, armour & outer sheath.


iv. Colour coding.

v. Conductor continuity test.

vi. Mutual Capacitance test.

vii. Capacitance Unbalance test.

viii. Insulation resistance test.

ix. High Voltage test.

x. Armour Galvanisation Test.

xi. Conductor Annealing Test.

xii. Measurement of drum length.

6.3.2 **Special Tests**

The non jelly filled cables shall also be subjected to following special tests.

i. Oxygen Index test as per IS-l 0810 (Part 58).

ii. Flammability test on finished cable as per IS-I0810 (part 61 & 62).

The special test shall be conducted on one sample from each lot. The sample will be selected by the inspector.

7.0 **PACKING AND DESPATCH**

7.1 Cables shall be despatched in non-returnable wooden drums of suitable barrel diameter, securely battened, with the take-off end fully protected against mechanical damage. The wood used for construction of the drum shall be properly seasoned, sound and free from defects. Wood preservatives shall be applied to the entire drum. Ferrous parts used shall
be treated with a suitable rust preventive finish or coating to avoid rusting during transit and storage.

7.2 On the flange of the drum, necessary information such as project title, manufacturer's name, type, size, length of cable in meters, drum no., cable code, BIS certification mark, gross weight, 'Owner's particulars', 'P.O. numbers' etc., shall be printed. An arrow shall be printed on the drum with suitable instructions to show the direction of rotation of the drum.

7.3 Cables shall be supplied in drum lengths of 1000 meters, if not specified otherwise.

7.4 A tolerance of plus or minus 5% shall be permissible for each drum. However overall tolerance on each size of cable shall be limited to ±2%. Offers with short/non-standard lengths are liable for rejection.

7.5 For non jelly filled cable, PVC / rubber end caps shall be supplied free of cost for each drum with a minimum of eight per thousand meter length. In addition, ends of the cables shall be properly sealed, with caps, to avoid ingress of moisture/water during transit and storage.

7.6 For jelly filled telephone cables, the ends of the cable shall be sealed by thermo shrinkable end caps of adequate wall thickness. Alternately ends may be sealed by enclosing them in rubber or PVC caps of wall thickness not less than 1.8mm. The caps shall be secured to the outer sheath with hose clips or ties or black adhesive tape or heat shrinkable sleeves.

7.7 The cables may be stored outdoors for long periods before installation. The packing shall be suitable for outdoor storage in areas with heavy rains / high ambient temperature, unless otherwise agreed.
TECHNICAL SPECIFICATION

FIRE DETECTION AND ALARM SYSTEM
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Abbreviations:

BIS  Bureau of Indian Standards
BASEEFA  British Approvals Service for Electrical Equipment in Flammable Atmosphere
CCE  Chief Controller of Explosives
CFAP  Central Fire Alarm Panel
CMRI  Central Mining Research Institute
CPU  Central Processing Unit
DGFAP  Data Gathering cum Fire Alarm Panel
ERTL  Electronic Regional Test Laboratory
FAT  Factory Acceptance Tests
FDD  Floppy Disk Drive
FM  Factory Mutual
FRP  Fibre Reinforced Plastic
FO  Fibre Optic
GUI  Graphic User Interface
HAB  Hooter acknowledgement box (to mute hooters)
HDD  Hard Disk Drive
ISDN  Integrated Service Digital Network
ITU-T  International Telecommunication Union- (Telecom)
LED  Light Emitting Diode
LPC  Loss Prevention Council
LIFO  Last In First Out
MCP  Manual call point (break glass unit; BGU)
MMI  Man Machine Interface
MR  Material Requisition
Ni-Cd  Nickel Cadmium (battery)
PO  Purchase Order
RF  Radio Frequency
SAT  Site Acceptance Tests
SOE  Sequence Of Event
TAC  Tariff Advisory Committee
UWL  Under Writers Laboratory
UPS  Uninterrupted Power Supply
VRLA  Valve Regulated Lead Acid (battery)
WP  Weather Proof
ZFAP  Zonal Fire Alarm Panel
1.0 SCOPE

1.1 The intent of this specification is to define the functional and design requirements for an Integrated Fire Alarm System for industrial plants and buildings. This specification covers the requirements for selection, design, and engineering, manufacture, testing at vendor's works, supply, installation, testing at site and commissioning of the system.

1.2 The Integrated Fire Alarm System shall be conventional or microprocessor based analog addressable system comprising of MCP, detectors; conventional or microprocessor based Fire Alarm panels, CFAP and associated equipments detailed hereunder and in Project data sheets/ drawings.

2.0 CODES AND STANDARDS

2.1 The system and equipment shall comply with relevant BIS (Bureau of Indian Standards) and other Indian/ International standards, as applicable. In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMAINFPA or equivalent agency shall be applicable. In case of imported equipment, the standards of the country of origin shall be applicable if these standards are equivalent or more stringent than the applicable Indian standards.

2.2 The equipment shall also conform to the special requirement/ provisions of applicable statutory regulations currently in force in the country.

2.3 In case of any contradiction between various referred standards/ specifications/ data sheets and statutory regulations, the following order of decreasing priority shall govern:

- Statutory regulations
- This specification
- Codes and standards

2.4 The fire alarm system and the components used shall conform to the latest edition of the following and also the other Indian and International Standards as applicable.

- IS-5 Colours for ready Mixed Paint & Enamels.
- IS - 513 Specification for cold rolled low carbon steel sheets and strips
- IS-2148 Flameproof enclosures for electrical apparatus
- IS - 1646 Code of practice for fire safety of buildings (general): Electrical Installations
- IS - 2175 Specification for heat sensitive fire detectors for use in automatic fire alarm system
- IS - 2189 Code of practice for selection; installation and maintenance of automatic fire detection and alarm system.
IS - 3034  Code of practice for fire safety of Industrial buildings: Electrical generating and distributing stations

IS - 3700  Essential ratings and characteristics of semi conducting devices (Applicable parts)

IS - 3826  Connectors for frequencies below 3 kHz General requirements Part-I and tests

IS - 5469  Code of practice for the use of semi-conductor junction devices (Applicable parts)

IS - 5780  Specification for Intrinsically safe electrical apparatus and circuits

IS - 11360  Specification for smoke detectors for use in automatic electrical fire alarm system.

IS - 12459  Code of practice for fire safety in cable runs

IS - 13346  General requirements for electrical apparatus for explosive gas atmosphere

IS-14154 Part 2  Electrical apparatus with protection of enclosure for use in the presence of combustible dust

NFPA 72 Vol 4  National Fire Alarm code

LPC  Loss prevention council recommendations.

BS - 5839  Specifications for manual call points.

BS-EN 50081-1  EMC (Electromagnetic compatibility test)

BS-EN 50082-1  EMC (Electromagnetic compatibility test)

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of the art technology and a proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply. The spares shall be available ex-stock with the vendor.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and PMC before phasing out the product/spares to enable the end user to place order for spares and services.

3.4 The vendor shall be responsible for design, engineering and manufacturing of the complete system and equipment to fully meet the intent and requirements of this specification and attached data sheets.
3.5 All equipment and accessories required for completeness of the system, whether specifically mentioned or not but considered essential for satisfactory performance, shall be included as a part of the offered system.

3.6 The system integrator shall coordinate with the manufacturers of various bought-out items associated with the system, as required, and shall freely and readily supply all technical information as and when called for.

3.7 Equipments to be located in hazardous areas shall have test certificates issued by recognized independent test house such as CMRI, ERTL, BASEEFA, UL, FM or equivalent. All indigenous equipment shall conform to Indian standards and shall be certified by Indian testing agencies. All equipment (indigenous & imported) shall also have valid statutory approvals as applicable for the specified location. All indigenous flameproof equipment shall have valid BIS license and marking as required by statutory authority.

4.0 DEFINITIONS

4.1 CFAP

It is a fire alarm panel located in fire station or in disaster management control rooms. It is electronic for conventional and microprocessor based for addressable system. CFAP is designed to gather information from distributed fire alarm panels provided in the plant/buildings and have features such as provision to activate plant-wide sirens, have interface with telephone exchange, plant's public address system etc. It has mimic for geographical display of alarms either on panel or as graphic displays on MMI.

4.2 DGFAP

It is a Microprocessor based fire alarm panel, designed for use with addressable fire alarm system. It has alpha-numeric LCD displays along with LED displays for fire/fault conditions. It also includes loop cards (for field devices), I/O cards for interface with other Purchaser's equipment, exit sign and hooters. It functions as fire alarm panel located centrally to population of fire detectors distributed over an area for optimizing and limiting the loop lengths.

4.3 ZFAP

It is a fire alarm panel for conventional fire alarm system. This has functionality similar to what is provided for DGFAP. This has LEDs for fire/fault annunciations.

4.4 Repeater Panel

It is similar to distributed fire alarm panels (DGFAP/ZFAP) but will not have Zone card/Loop card for field devices. These are provided at manned locations and are configured to acquire information about the fire/fault of selected zones from DGFAP/ZFAP and annunciate.
4.5 Integrated Fire Alarm System

It signifies a comprehensive fire alarm system comprising all the distributed fire alarm panels (DGFAP, ZFAP, repeater panels etc) having integration with CFAP for fire monitoring of total plant/building. It provides audio/visual alarm building/plant-wide having provisions for connectivity with telephone exchange, pager system and public address system. It shall provide interfaces with fire protection system and other systems like pressurization systems, air conditioning etc.

4.6 System Architecture

System architecture is line diagram defining the connectivity of DGFAPs, repeater and CFAP. This also specifies various system requirements such as redundancy, communication protocol, communication hardware, cable requirement, workstation and programming tools.

4.7 Data High Way

This term is meant to define the communication path between DGFAPs, CFAP and other network components in microprocessor based fire alarm system. Physical media for Data highway can be fibre optic (FO) cable or twisted pair copper conductor, screened cable.

4.8 Field Devices

Devices such as detectors, MCP, exit signs, hooters, siren etc. are termed as field devices.

4.9 HAB

This term is defined as Hooter Acknowledgement Box. HAB for individual buildings shall be provided at its exit.

4.10 Hazardous Area

An area in which an explosive gas/dust atmosphere is present, or likely to be present in quantities such as to require special protection for the construction, installation and use of electrical apparatus.

5.0 SYSTEM AND SITE CONDITIONS

All equipment shall be designed to operate with power supply and site conditions as specified below:

5.1 Input Power Supply

5.1.1 Unless stated otherwise, purchaser shall provide one point power supply to each fire alarm panel (ZFAP/DGFAP/CFAP/repeater panel), details of which are indicated in data sheet. A suitable power distribution to various equipment and sub system shall be included in vendor's scope.

5.1.2 Power supply for fire alarm panels shall have battery back up as per IS-2189. Battery AH rating shall be determined on the basis of maintaining the system in normal operation for a
period of not less than 48 hours (quiescent condition) and successive full load alarm condition of period not less than 30 min after the failure of normal mains supply.

The switch over from mains to back up, in the event of mains failure, shall be automatic. Batteries shall be Ni-Cd/ VRLA type as specified in data sheets. Suitable and adequately rated battery charger shall be supplied as a part of back up battery system.

(The full load alarm condition is defined as operation of all panel/field audio and visual alarm and the alarm load of 25 percent of total zones besides other normal operation loads.)

5.2 Site Conditions

The offered equipment shall be capable of operating continuously and maintaining its guaranteed performance at the site ambient conditions indicated in data sheet.

Unless specified otherwise, fire alarm panels along with associated hardware shall be suitable for installation and operation in a closed building/ room with restricted ventilation. Any specific requirements for air conditioned/ dust free environment, etc. for the panels, if absolutely necessary, shall be clearly highlighted by the vendor in the offer.

6.0 FIRE ALARM SYSTEM DESCRIPTION

6.1 General

Fire alarm system under this specification is envisaged to provide fire monitoring in industrial plants/ chemical plants/ plant and non-plant buildings. The system shall be designed to detect incipient fires and generate audio/ visual alarm in case of fire.

The system shall consist of automatic fire detectors and manual call point or break glass unit. Automatic fire detectors shall work on the principle of sensing of smoke, heat or infrared rays. Depending on type of smoke, optical or ionization type detectors shall be used. Detectors shall generally be provided in plant/ non-plant buildings. Manual Call Point shall be provided at exit doors of the buildings and at exit route of industrial plants. Number of detectors and break glass unit shall be decided as per guidelines given in applicable codes and standards.

The plant/ building shall be divided into fire monitoring zones. Detectors and MCP at these buildings and plants shall be connected to DGFAP/ ZFAP. These panels shall continuously monitor the state of these devices. On sensing fire condition, an audio/ visual alarm shall be initiated identifying the zone where fire is detected. Panels shall continuously monitor the health of the cabling and in case of short circuit or open circuit fault alarm shall be actuated. Fire alarm panels shall also have powered outputs for switching on exit signs and hooters as specified in data sheet. Further, panels shall provide required output for interfacing with the Purchaser's systems such as air conditioning system or pressurization system or fire protection systems.
Alarms, if specified, shall be relayed to repeater panel provided in buildings like control rooms/administrative buildings to provide zone wise annunciation. In addition facility shall be provided to actuate siren/ hooter.

For integrated fire alarm system where plant-wide large numbers of fire alarm panels are envisaged, these panels shall be integrated to CFAP, which shall be located in fire station or in administrative control room of the building as per the job requirements. The connectivity shall be achieved using data high way or dedicated cable connection from each fire alarm panel to CFAP. Mimic at CFAP shall be provided for fire/ fault annunciation on geographical location in addition to the text/ LED. If defined, CFAP shall have provision for automatic and manual actuation of plant-wide siren as per operator's choice. Interface with other systems such as telephone exchange/ plant's public address system/Pager system shall be provided for communication required for disaster management.

6.2 Conventional/Addressable fire alarm systems

Fire alarm system shall be conventional fire alarm system or microprocessor based fire alarm system as specified in data sheet. Conventional fire alarm system shall have conventional field equipment and Microprocessor based system shall have addressable type field devices.

6.2.1 Conventional fire alarm system shall generally comprise but not be limited to the following equipment used in conjunction with conventional automatic fire alarm detectors and manual call points as a minimum.

i. CFAP with/ without mimic (as per data sheet)
ii. ZFAPs
iii. Repeater Fire Alarm Panel
iv. Plant-wide Sirens and starters
v. Hooters, exit sign and HAB in buildings
vi. Interface with Purchaser's systems
vii. Any other hardware as required to render system complete

6.2.2 Microprocessor based fire alarm system shall generally comprise but not be limited to the following equipments used in conjunction with addressable automatic detectors and addressable MCP as a minimum.

i. CFAP consisting of computer based graphic workstation and engineering station.
ii. Multi loop DGFAPs
iii. Plant-wide sirens and starters
iv. Hooters, exit sign and HAB in buildings
v. Interface with Purchaser's systems

vi. Dual redundant copper/ FO cable data highway complete with dual redundant architecture for communication hardware including communication port, switches, processor and power supply

vii. Any other hardware/ Software required for rendering system complete

6.2.3 As specified in data sheet, the system shall be provided with siren/s to be located at a suitable location/s in the plant and it shall be actuated manually and automatically as selected by operator from CFAP/ DGFAP located at fire station/ other buildings.

7.0 CONVENTIONAL FIRE ALARM SYSTEM

7.1 Design Features

7.1.1 The system shall be modular and shall facilitate future extension / modification. Panel design and component selections shall be done for future extension up to 100/0 of specified zones or one zone whichever is maximum in each panel. The design of common facility and hardware shall be provided for required future extension of zones.

7.1.2 PCBs shall have watchdog feature for self-diagnostic. Each PCB shall have LED for annunciating card failure. Following self-diagnostic features may be considered as minimum.

i. Open loop detection

ii. Short circuit detection

iii. Earth faults

iv. Power supply failure e.g. low battery voltage, main incoming supply fail

v. System faults (PCB failure)

7.1.3 Logic of operation shall be built on "Fail safe" feature i.e. NC contact of field devices shall be considered as healthy condition and NO as fire condition. 1NO+ 1NC contact of output relays shall be wired to terminal block for interface with Purchaser's other equipment.

7.1.4 It shall be possible to test lamps, hooters, flasher circuit, and functional tests etc through common "Test" push button.

7.1.5 The circuit shall be so designed that silencing of the current alarm by ACCEPT push button shall not prevent annunciation of subsequent fire alarm received from any other location

7.1.6 Signal-to noise ratio shall be high to avoid spurious actuation due to noise induced in the field wiring because of proximity with power cables. Cables for field devices shall be multicore copper conductor, unscreened, armoured, copper conductor cable. If required noise filters shall be provided at fire alarm panel.
7.1.7 Detectors and MCPs in a loop shall be wired through 1.5 mm² multi-core, Copper conductors, PVC insulated, armoured cable. Limiting distance from fire alarm panel to last detector/MCP shall not be less than 2 km or as specified in data sheet whichever is maximum.

7.1.8 LEDs shall be provided for fire/ fault visual annunciation on the panel front. LED shall also be provided for Power supply healthy, Battery backup ON, Battery/ Charger status.

7.1.9 If zone is protected with clean agent/ CO2 system, the detectors and MCPs of the zone shall be wired in cross-zones by providing minimum two loops in a zone. The last device in each loop shall be provided with end of line resistor of suitable value as per circuit design to facilitate cable open circuit and short circuit detection.

7.1.10 Scheme for FIRE/ FAULT annunciation shall be as per the following.

<table>
<thead>
<tr>
<th>SYSTEM CONDITION</th>
<th>AUDIO</th>
<th>VISUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORMAL</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>FIRE</td>
<td>OFF</td>
<td>ON (tone 1) Flasher ON, Fire LED Steady ON</td>
</tr>
<tr>
<td>Accept</td>
<td>OFF</td>
<td>Flasher steady, Fire LED steady ON</td>
</tr>
<tr>
<td>Reset</td>
<td>OFF</td>
<td>Flasher OFF, Fault LED OFF</td>
</tr>
<tr>
<td>FAULT</td>
<td>ON (tone 2)</td>
<td>Flasher OFF, Fault LED Steady ON</td>
</tr>
<tr>
<td>Accept</td>
<td>OFF</td>
<td>Flasher OFF, Fault LED Steady ON</td>
</tr>
<tr>
<td>Reset</td>
<td>OFF</td>
<td>Flasher OFF, Fault LED OFF</td>
</tr>
</tbody>
</table>

7.1.11 Fire alarm panels including repeater panels and CFAP shall be certified/ approved by applicable approving agency of country of origin as required.

7.2 Zonal Fire Alarm Panel

7.2.1 ZFAP shall consist number of zones as specified in data sheet. Detectors/MCP/ heat sensing cables etc shall be connected zone wise in a loop. It shall monitor fire/ fault condition of the zone. ZFAP shall be located indoor in safe area.

7.2.2 ZFAP shall be free-standing, floor mounting vertical panel consisting of audio/visual annunciation with Alarm Accept; Test and Reset Push Buttons, Auto/Manual control of hooters provided in buildings. Provision to actuate siren shall be provided if specified in data sheet. Circuit shall be designed to provide annunciation if any detector in a zone senses fire. Annunciation scheme shall be as per clause 7.1.10

7.2.3 Audio/ Visual indication and annunciation shall be as per clause 7.1.8.

7.2.4 ZFAP shall have required interface hardware where integration with CFAP/ repeater panel is envisaged as per data sheet.
7.2.5 Output contacts (1NO+ 1NC) shall be provided for interface with Purchaser's systems as per clause 9 of this specification. The rating of output contact shall be 0.5A, 220V DC or 2A, 240V AC.

7.2.6 Input power supply and battery backup for ZFAP shall be as per data sheet and as per clause 5.1 of this specification.

7.3 Repeat Alarm Panel-Conventional

7.3.1 Repeat fire alarm panel shall be similar to ZFAP except providing zones for detector loops. Fire/ fault annunciation of ZFAP shall be repeated to repeater panel. Annunciation scheme shall be as per 7.1.10 Depending on the size Repeat Fire Alarm panel may be floor mounting type or wall mounting type.

7.3.2 Where required, input power supply from purchaser shall either be 240V or 110V, 1 phase, 50Hz. It shall be possible to select supply either 240V or 110V at site without modifying or adding additional equipment in the panel.

7.4 Central Fire Alarm Panel

7.4.1 CFAP shall be located in fire station in plants or in building control room. Fire and fault annunciation for each Zone or group of zones at ZFAP shall be repeated at CFAP. Annunciation scheme at CFAP shall be provided as per the clause 7.1.10.

7.4.2 CFAP shall be in vertical panel construction or desk type construction having controls such as Accept, Test and Reset Push Buttons, Auto/Manual control of siren etc.

7.4.3 Unless otherwise specified in the data sheet, CFAP shall have mimic to display geographical location of fire. Mimic shall form an integral part of the CFAP and shall be located at the top of the panel. When separate mimic panel is specified, it shall either be wall mounting or freestanding floor mounted type. Two LEDs shall be provided for each zone on mimic panel for display of fire alarm. Mimic panel shall be powered by CFAP. Mimic made out of plastic stickers shall not be acceptable.

7.4.4 Input supply and battery backup for CFAP and MIMIC shall be as per data sheet and as per clause 5.1 of this specification.

8.0 MICROPROCESSOR BASED FIRE ALARM SYSTEM

8.1 Design Feature

8.1.1 Unless otherwise specified Microprocessor based system shall be analog addressable type. The system shall be integrated as per 'system architecture' indicated in data sheets.

8.1.2 Microprocessor based fire alarm system shall be designed to use state of the art technology. All fire alarm panels including repeater panel shall be networked through data high way. The system supplied shall not pose any limitation for future expansion by way of networking of fire alarm panels, data transfer, parameterization of addressable field devices, graphic displays etc.
8.1.3 The system shall be modular and shall facilitate future extension/ modification. Panel design and component selections shall be done for future extension up to 10% of specified zones or one zone whichever is maximum in each panel. The design of common facility and hardware shall be provided for required future extension of zones.

8.1.4 PCBs shall have watchdog feature for self-diagnostic. Each PCB shall have LED for annunciating card failure. Following self-diagnostic features may be considered as minimum.

   i. Open loop detection
   ii. Short circuit detection
   iii. Earth faults
   iv. Power supply failure e.g. low battery voltage, main incoming supply fail
   v. System faults (PCB failure)

8.1.5 Unless specified otherwise in data sheet, system architecture shall have minimum redundancy indicated below however not limited to the same.

   i. Dual redundant at processor level (communication processor and I/O card processor)
   ii. Dual redundant communication port
   iii. Dual redundant data highway cable
   iv. Dual redundant microprocessor at CFAP
   v. Dual redundant work station/MMI (engineering station+ operator's station)
   vi. Dual redundant power supply card at all fire alarm panels (but with single source of battery backup)

8.1.6 Data highway shall be Fibre optic or twisted pair shielded copper cable as specified in data sheets. Whether specified or not, data highway shall include all necessary hardware such as modem, repeaters, network switches/ hubs etc including power supply system as required to suit the length of data highway.

8.1.7 The communication shall be peer to peer between various OGFAPs, repeater Panels, CFAP and other system components connected on fire alarm system data highway.

8.1.8 Any fault in Analog detector addressable loop and data highway shall not impair communication i.e. Communication/ flow of analog signal shall be possible from either end of the loop.

8.1.9 The loop cabling for wiring detectors and MCPs shall be class A, fault tolerant type as per NFPA 72.

8.1.10 Fire alarm logic shall be programmable type. The logic for zone protected with clean agent system/ CO₂, shall be programmed to provide output for actuation after ensuring that there
is no false alarm. Similarly logic to switch ON the exit sign and sound the hooters shall be programmable type.

8.1.11 The logic shall be so programmed that silencing of the current alarm by ACCEPT push button shall not prevent annunciation of subsequent fire alarm received from any other location.

8.1.12 Signal-to noise ratio shall be high to avoid spurious actuation due to noise induced in the field wiring because of proximity with power cables. Unless otherwise specified, fire alarm cables laid in buildings shall be twisted pair, screened and unarmoured and shall be laid in conduits while cable laid outdoor in plant shall be twisted pair, screened and armoured. If required noise filters shall be provided at fire alarm panel.

8.1.13 Unless otherwise specified in data sheet, the minimum number of detectors/ MCP/ addressable devices in a signal loop shall be 60.

8.1.14 Unless otherwise specified in data sheet, conductor size of loop cable shall be 1.5 sqmm copper. The allowable signal loop length shall not be less than 2 km. To optimize length, circuit design for loop shall allow the use of spur connection.

8.1.15 DGFAP and repeater panel shall have backlit alphanumeric LCD display to provide addresses, status of each field device. In addition LEOs shall be provided for fire/ fault visual annunciation. LED shall also be provided for Power supply healthy, Battery backup ON, Battery/ Charger status.

8.1.16 Fire station shall be provided with dual redundant PC with monitor for operator's workstation and for engineering station. Any of the two should be possible to configure as engineering station for programming off line. After Programming, the engineering station will be connected to network as online operator's workstation. Programming shall also allow activating Siren from the keyboard in manual mode as per operator's choice.

8.1.17 Scheme for FIRE/ FAULT annunciation shall be as per the following.

<table>
<thead>
<tr>
<th>SYSTEM CONDITION</th>
<th>AUDIO</th>
<th>VISUAL</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>FIRE</td>
<td>OFF</td>
<td>Flasher ON, Fire LED Steady ON</td>
</tr>
<tr>
<td>Accept</td>
<td>OFF</td>
<td>Flasher steady, Fire LED steady ON</td>
</tr>
<tr>
<td>Reset</td>
<td>OFF</td>
<td>Flasher OFF, Fault LED OFF</td>
</tr>
<tr>
<td>FAULT</td>
<td>ON (tone 2)</td>
<td>Flasher OFF, Fault LED Steady ON</td>
</tr>
<tr>
<td>Accept</td>
<td>OFF</td>
<td>Flasher OFF, Fault LED Steady ON</td>
</tr>
<tr>
<td>Reset</td>
<td>OFF</td>
<td>Flasher OFF, Fault LED OFF</td>
</tr>
</tbody>
</table>

8.1.18 All field devices such as detectors and MCPs shall be addressable type. If available in vendor's design, hooters and exit sign may also be connected in addressable loop. Fault isolators shall be provided to minimize outage of number of detectors/ MCPs in case of loop cable fault. For hazardous area flame proof equipment shall be used. As far as
possible, the use of intrinsically safe field devices in hazardous area should be avoided. If unavoidable, due care shall be taken care in design to avoid signal distortion and thus the mal-operation due to cable capacitance and inductance.

8.1.19 System shall provide adequate EEPROM size to store minimum of 10 events fire/ fault. The event shall be stored in LIFO structure. All events shall be time stamped. DGFAP shall have real time clock for event time stamping.

8.1.20 Software access for either Zone programming or access to plant/ building graphic on monitor shall be password protected. For viewing status of various field devices e.g. fire and fault status password protection shall not be given.

8.1.21 Fire alarm panels including repeater panels and CFAP shall be certified/ approved by an international approving agency/ approving agency of country of origin as applicable.

8.2 Data Gathering Cum Fire Alarm Panel (DGFAP)

8.2.1 DGFAP shall have basic design features as per clause 8.1 above. Number of signal loops in each DGFAP shall be as defined in the data sheet. Number of loops shall be basic part of main PCB and should not be extended by providing external electronic devices. LCD display and annunciation scheme shall be as per clause 8.1.17.

8.2.2 It shall be possible to change the reference value of detector sensitivity either manually or automatically as required during the operation to avoid false alarms prior to detector maintenance.

8.2.3 DGFAP shall have serial port for communication to data highway. It should be possible to communicate all the information to CFAP/ FA system workstation located with fire marshal. The protocol of communication shall preferably be open protocol.

8.2.4 In the event of non-availability of data highway, DGFAP shall work as stand alone intelligent panel monitoring fire in the zones connected to it.

8.2.5 It shall be possible to configure DGFAP to access data of any other DGFAP and display as per the operation requirement to be finalized during engineering/ commissioning.

8.2.6 It shall be possible to interface with existing fire alarm system consisting of conventional zone detectors and MCPs with end of line resistor as a part of retrofitting.

8.2.7 DGFAPs shall have output relays to provide interface with Purchaser's system defined in clause 9 as minimum.

8.3 Repeat Alarm Panel

8.3.1 These panels shall be required for repeat of alarm in building/ plant control rooms. These panels shall be similar to DGFAP and shall be connected to data highway through serial communication. Panels shall have programming facility to inhibit the display of information that is not required in a particular repeater panel.

8.4 CFAP/ PC based monitoring station or Work station
Based on vendor's system design CFAP shall include network PC based monitoring station directly connected to data highway with other peripherals such as network switches/ controller (HUB). Alternatively, vendor may supply CFAP similar to DGFAP along with PC based monitoring station. Application software shall be installed in PC as GUI. The graphic shall include geographical location of various plant areas including location of addressable detectors and MCPs. The navigation between various graphic pages shall be user friendly. The screen shall have defined area to display the latest fire or fault alarm and shall also have facility to pop up the graphic displaying the location of fire event.

8.4.2 Unless stated otherwise, CFAP shall have all the features and facilities of the DGFAPs. It shall monitor the status of each addressable field device indirectly from the DGFAPs connected on data highway.

8.4.3 Engineering workstation shall be used for programming off-line. After programming, the changed parameters shall be down loaded to other PC to work in synchronism as normal operation. This station shall also have two printers connected to PCs working as SOE printer and engineering printer. SOE printer shall be high-speed dot matrix printer and engineering printer shall be laser printer.

8.4.4 Unless specified otherwise, adequately rated UPS with bypass shall be provided for PC based monitoring station. Battery backup shall be sized as per criteria given under 5.1. Only normal supply shall be made available at one point by Purchaser at the location of central fire alarm panel.

8.4.5 It shall be possible to actuate plant-wide siren in auto/ manual mode. Unless otherwise specified, manual actuation shall be done from keyboard of workstation. Auto actuation shall be through software logic, which shall be finalized with end user during implementation. Auto/Manual selection shall be provided at operator's workstation. The actuation signal under manual mode selection shall be communicated serially to DGFAP to which siren starter is connected. Siren starters shall be hardwired to DGFAP.

8.4.6 The minimum requirements for the PC and other peripherals shall be as stated below:

* Industrial type Latest generation PC
* 1.44 MB Floppy drive
* CD-ROM
* Mouse and keyboard
* 21 Inch coloured monitor with flat screen
* SOE dot matrix printer
* Engineering laser jet coloured printer with 8 PPM
Application software supporting graphics with no limitation on number of graphics, events, alarms, number of field devices as required for any large plant like refinery, petrochemical complex or the large multistory building.

8.4.7 It shall be possible to provide multilevel access of fire alarm system. Read only access shall not require password protection. Access for programming and access for controls from keyboard shall be password protected. The levels of password protection shall be agreed with plant operators at the time of commissioning of system.

8.4.8 Printer

i. Printer options shall include both graphic laser printer and dot-matrix event text printer.

ii. Printer used in the system shall provide real time records of the system events and provide system reports on demand, and shall be microprocessor controlled, high speed, read only (RO) letter quality dot-matrix type 132 characters wide and 96 character set.

9.0 INTEGRATION WITH VARIOUS PLANT SYSTEMS

9.1 Fire Alarm System shall have required hardware to have interface with following plant systems as specified in data sheet.

i. Public Alarm Announcement system

ii. Paging and plant intercom systems.

iii. Plant data network

iv. ISDN telephone exchange and pager system

v. Fire suppression system

9.2 ZFAP as a minimum shall be provided with the following interface with fire suppression system unless specified otherwise.

i. Automatic signal for release of clean agent/CO₂, release for protected area and RELEASE audio/ Visual alarm for evacuation.

ii. Selector switches for primary or secondary clean agent/CO₂ supply for each protected area.

iii. Manual push button for discharge of clean agent/CO₂, in each protected area. The actual release of clean agent/ CO₂ shall however be delayed by 30 sec after the alarm.

iv. Clean agent/CO 2 Discharge inhibit push button for each protected rea.

v. Deluge valve activation push buttons, deluge valve test push buttons and deluge valve activated status lamps.
vi. Shutdown signals to various air-handling units relative to the zone of fire.

vii. Firewater pumps start push buttons.

viii. Firewater pumps running indications.

10.0 PANEL CONSTRUCTION (CFAP, DGFAP, ZFAP, REPEATER)

10.1 All fire alarm Panels shall be free standing, floor mounting type unless specified otherwise and shall be fabricated out of minimum 2mm thick CRCA sheets and doors shall be fabricated out of minimum 1.6mm CRCA sheets. The panel shall be naturally ventilated in IP-41 enclosure protection as minimum.

10.2 Equipment Mounting

10.2.1 All apparatus, display screen, instruments and indicating lamps mounted on the panel front shall be flush mounting type. The external cabling shall not be terminated directly on the base connector of PCBs but shall be terminated on separate terminal block. Further connection to PCBs shall be as per manufacturer's standard. Routine calibration, adjustments, programming and operation shall be accessible from the front of the panel without opening the door. External cabling shall preferably be done from the rear.

10.2.2 Power supply system including battery bank shall be mounted inside the panel.

10.2.3 Doors shall be provided with pistol grip handle with lock. Lamps shall be provided inside the panel to provide adequate light for maintenance of equipments.

10.2.4 Cable entry shall be from bottom unless otherwise specified in the data sheet. Terminal strip shall be provided for incoming / outgoing cables.

10.3 Wiring and Terminals

10.3.1 Wiring within the panel shall be laid in slotted plastic raceways enclosed with cover. Control connections shall be done with 660V grade PVC insulated wires having stranded copper conductors. 1.5mm² size of wire shall normally be used for circuits with control fuse rating of 10A or less. Control wiring for electronic circuits shall be through ribbon cable or through copper wire minimum of 0.5mm dia. Panels shall be supplied completely pre-wired, such that only field termination shall be required at site before it is energized.

10.3.2 PCBs for identical functions shall be interchangeable. PCBs shall be plug in type having pin/edge connectors. PCBs shall be suitable for use in tropical, humid and dusty environment. These shall be protected with anti fungus treatment.

10.3.3 Cables shall be terminated on terminal blocks. Clamp type terminals shall be of spring-loaded, stacking type, mounted on rails. Terminals shall be sized to accept, as a minimum 2.5mm² cross section conductors. Not more than one conductor shall be terminated on the outgoing side of each terminal. At least 20% spare terminals shall be provided in each panel for termination of spare cores of cables.

10.4 Earthing
10.4.1 A common earth bar of minimum 25 x 3 mm. copper or equivalent aluminium shall be provided throughout the length of the panel. All non-current carrying metallic parts of the panel mounted equipment shall be earthed. Flexible jumpers shall connect all doors and movable parts to the earth bus. Two numbers earth lugs shall be provided outside the panel.

10.5 Name Plates / Warning plates

10.5.1 All nameplates for panel shall be engraved out of 3 ply (black-white-black) lamicoid sheets or anodized aluminum. Back-engraved Perspex sheet nameplates will also be acceptable. Engraving shall be done with square groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable.

10.5.2 Labels shall be provided for every component on the cards, connecting wires as well as for the terminals in the terminal strip inside the panel. Wiring diagram shall be pasted inside the panel door as required for termination and maintenance.

10.5.3 Special warning plates shall be provided on all removable covers or doors giving access to energized metallic parts above 24 volts.

10.6 Painting

10.6.1 All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The undersurface shall be made free from all imperfections before undertaking the finishing coat.

10.6.2 After preparation of the undersurface, the panel shall be powder coated. The colour shade of final paint shall be as approved by the purchaser. The finished panels shall be dried in dust free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, fun-off paint etc.

10.6.3 All unpainted steel parts shall be cadmium plated or suitably treated to prevent rust-corrosion. Moving elements shall be greased.

11.0 CABLE AND CABLE ACCESSORIES

11.1 Unless otherwise specified, purchaser shall supply and lay only the following cables.

i. Signal Loop/ Zone Cables from outdoor field devices to the fire alarm panel except for buildings.

ii. Loop/ Zone cables from FA panel to JB (Vendor shall provide JBs in each building for signal loop cabling. Cables from J8 to fire alarm panel is included in purchaser's scope while cable from JB to detectors and all other field devices shall be included in vendor's scope.)

iii. Exit sign and hooter cables from FA panel to JB (Vendor shall provide separate JB for exit sign and hooter. Cables from JB to fire alarm panel is included in Purchaser's scope while J8 to exit sign and hooter is included in vendor's scope.)
iv. Cable from purchaser's switchgear to siren starter and siren starter to siren.

v. All interface cables from fire alarm panels to purchaser's system.

vi. Incoming power supply cables from purchaser's switchgear to Fire Alarm Panels All other cables as required for fire alarm system including the supply, laying and termination of cables and accessories within buildings from JBs to detectors/ MCPs, exist signs, hooters and also supply, laying, termination of data high way cables, high way accessories etc as required for successful commissioning shall be in vendor's scope.

11.2 Though the supply and installation of field cabling is excluded from vendor's scope but terminations of all cables (supplied by both vendor/ purchaser) at both ends shall be in vendor's scope.

11.3 Bidder, as a part of integration and selection of fire alarm equipment, shall furnish detailed specifications for loop/zone cables, data highway cables, cables for hooter/exit signs etc giving details such as type of cables, number of pairs, size of cable, inductance and capacitance data, number of fibres/ connectors etc.

11.4 Data Highway Cables

11.4.1 Unless specified otherwise, vendor shall supply Copper cable/ FO type data highway cable to suit system design and equipment specification. Copper cables, if supplied, shall be of adequate size, twisted pair, PVC insulated, overall screened, PVC inner sheathed, armoured, FR type PVC outer sheathed as the minimum requirement. Fibre Optic cables, if supplied, shall be armoured, overall FR PVC outer sheathed and shall be as per ITU-T recommendation as a minimum.

11.4.2 Vendor shall supply and install all hardware and cabling accessories as per data high way design including modems, repeaters etc as part of the FA system. Modems/ repeaters shall be powered by the supply provided for DGFAPs / CFAP.

11.5 Cable Glands / Accessories

11.5.1 All cable glands/ lugs/ connectors as required for the equipment shall be included in vendor's scope and shall be supplied along with the system, irrespective of whether installation is to be performed by vendor or not.

11.5.2 All the cable glands for outdoor application shall be weatherproof, nickel-plated brass and double compression type, whereas those for indoor application shall be single compression type.

11.5.3 Cable glands for hazardous area equipments shall be flameproof, weatherproof and nickel plated brass double compression type.

12.0 AUTOMATIC FIRE DETECTORS AND ACCESSORIES

12.1 General Specifications
| 12.1.1 | Detectors for conventional fire alarm system shall be conventional type. End of line resistor shall be provided at the last detector in the zone. Detectors for microprocessor shall be addressable type. Detectors shall be plug-in type and shall have twist lock action fitting. Multicolour LEOs provided on the detectors shall indicate Normal and Alarm state. Essential features of detectors are indicated as below. |
| 12.1.2 | Detectors shall be supplied with mounting bases. Mounting base shall be identical for all type of detectors except special application detectors such as linear beam detectors etc. for installation as well as cable connection. Detector housing (body and cover) shall be made up of damage resistant, fire resistant polycarbonate and shall be suitable for either surface or recess mounting. Detector base shall be mounted on Junction boxes having terminals for cable termination. Where installation is included in vendor's scope, equipment such as GI conduits, GI junction box/conduit box etc. shall also be included in vendor's scope. |
| 12.1.3 | Detectors shall be suitable for storage at ambient condition specified in data sheet. |
| 12.1.4 | Detectors, which employ Radio Active source, shall be such that the strength of the Radio Active material shall not exceed 1 micro curie or as per latest standard whichever is less. |
| 12.1.5 | All detectors shall be on the approved list of LPC, UL / FM/ equivalent international approving agency as applicable. |
| 12.1.6 | All detectors shall be suitable for operation at DC power supply extended from fire alarm panel. |
| 12.1.7 | The addressable detectors shall be continuously monitored to measure changes in their sensitivity due to the environment (dirt, dust, temperature, humidity etc.). These detectors shall give an advance indication to the panel regarding the need for maintenance. The analogue reading sent by the detectors shall be sensed and if there is a rapid increase, an alarm shall be generated. However, if there is a gradual increase in the analogue reading, a maintenance alert shall be generated by the fire alarm panel. It shall be possible to generate maintenance reports from the fire alarm panel. For the addressable detectors two-wire operation shall be possible. |
| 12.1.8 | All addressable detectors shall have selectable settings for pre-alarm and alarm and preferably have the facility to set the sensitivity and address from the fire alarm panel. |
| 12.1.9 | Manual call points / break glass boxes for microprocessor based fire alarm system shall be addressable type. Each device shall have its own address module. |
| 12.1.10 | All addressable detectors shall be suitable for installation using fault tolerant wiring (class-A, style - 6 wiring as per NFPA72). T- Tapping shall not be permitted in the case of such wiring. |
| 12.1.11 | All detectors must have insect screen to prevent entry and cause false alarm. |
| 12.1.12 | All field devices shall be from the latest generation in the manufacturer's range of products. Commonly used field devices are listed below. The specification given shall be considered as the minimum requirements. |
12.2 Heat Detectors

12.2.1 Heat detectors shall use negative temperature coefficient thermisters for sensing and for reference. The detector shall be designed to give a response that depends on both absolute temperature and rate of rise in temperature.

12.2.2 The rate of rise element shall be carefully calibrated to ignore any normal fluctuation in temperature, but to respond quickly when the temperature rise is 9°C or more per minute.

12.2.3 The fixed temperature feature should be entirely independent of the rate of rise element. The operating temperature of fixed temperature element should be factory set at 57° C ± 5° C.

12.2.4 The detector shall be self-restoring type ensuring repeated use and easy maintenance.

12.3 Ionization Smoke Detector

12.3.1 Ionization smoke detector shall be solid-state type, working on ionization principle and shall preferably be of dual chamber and dual source type.

12.3.2 The detector shall be able to sense incipient fire by detecting the presence of visible and invisible products of combustion like wood, paper, ammonia processing paper, cloth, PVC, bakelite, nylon, foam, acrylic, thermocol, Photo film, nylon, polyester, painted sheets, Teflon, leather etc.

12.3.3 The sensitivity of the detector shall not vary with change in ambient temperature, humidity, pressure or permissible voltage variation. Its performance shall not be affected by an air current of 5 m/sec. It shall have an inbuilt arrangement such that puffs of smoke or hot air pockets do not inadvertently trigger the alarm. The detector shall be protected against dust accumulation/ ingress. It shall have insect resistant screen to prevent nuisance alarms.

12.3.4 Where air velocity is expected to be higher, smoke guard/ baffle shall be used.

12.3.5 Where specified, smoke detectors operating on laser diode principle shall be offered.

12.4 Photo Electric / Optical Smoke Detector

Photo electric/ optical smoke detectors shall work on the principle of light scattering utilizing a light emitting diode.

12.5 UV Flame Detectors

12.5.1 UV flame detectors shall work on the principle of a vacuum photodiode tube to detect the UV radiation that is produced by a flame.

12.5.2 UV flame detectors shall respond to ultraviolet rays of a flame. The detector shall not be actuated by artificial lights, sunlight incident through a windowpane or welding arc. False alarm check circuit shall be incorporated to prevent false alarm due to intermittent flash or lightning.
12.6 **IR Detectors**

12.6.1 IR detectors shall work on the principle of a single wavelength infrared flame detector using one of several different photocell types to detect the infrared emissions in a single wave length band that are produced by a flame.

12.6.2 IR detectors shall react to the infrared rays of a flame. It should be sensitive enough to detect smoky fires in which flame is hardly recognizable. The detector should not react to extremely glaring artificial light or direct sunlight. The detector shall be completely solid-state type.

12.6.3 Where specified combination UV-IR detector shall be used.

12.7 **Linear Beam Detector**

12.7.1 Linear beam detector shall work on the principle of obscuration of infrared light beam by particles of smoke. The sensitivity shall be such as to enable operation at 30% to 500% obscuration.

12.7.2 Linear beam detector shall consist of separate transmitter and receiver. Linear beam detector shall be suitable for application in high roofed locations such as warehouses etc. The detector shall, preferably, be powered from the loop signal itself. However, if external power supply is required the same shall be explicitly stated by the vendor, which shall be covered under common power supply for the fire alarm panel and devices connected with it.

12.8 **Heat Sensing Cables**

12.8.1 Heat sensing cable shall be analogue type. It shall consist of four copper conductors, each covered with a colour coded, negative temperature co-efficient material. The cores shall be twisted together and protected by an outer sheath of high temperature, flame retardant PVC insulation. External mechanical protection shall be provided over the sensor cables. Vendor shall provide control unit for each 100 m length of the sensor cable.

12.9 **Manual Call Point (MCP)/ Break Glass Unit (BGU)**

12.9.1 Manual break glass unit shall be fabricated out of 14-gauge cold rolled sheet steel. Alternately the break glass unit may be made of die cast aluminum alloy such as LM6. It shall have IP-55 enclosure and weatherproof construction suitable for outdoor installation. The break glass unit shall have a minimum dimension of 100x100x80mm.

12.9.2 The box shall be fabricated in such a way it can be mounted flush to the wall or on the surface without any modification. Two nos. 19 mm knockouts shall be provided at the bottom of the box to facilitate cable / conduit entry. The glass shall cover at least 30cm² area and shall have a thickness not exceeding 2mm.

12.9.3 The box shall have a push button element kept in pressed condition by a glass sheet fitted in the front of the box.
12.9.4 The enclosure shall be painted with fire red colour (shade 536 of IS-5) epoxy painting and an inscription "Break Glass in case of Fire", shall be painted in white letters or riveted on the enclosure by a steel nameplate. A suitable nickel-plated brass hammer, duly chained to the box with stainless steel chain shall be provided with each box for breaking the glass. Each box shall have a distinct identification number boldly painted on it.

12.9.5 If specified in the data sheet, the BGU shall have a suitably wired telephone hand set to facilitate communication between the BGU and the central annunciation panel. Telephone hand set mounted on hook switch shall be housed in a separate lockable weatherproof break glass window enclosure. The glass will be broken in case of fire with the hammer provided with the BGU.

12.9.6 Hazardous area Break Glass Units shall meet the requirement of clause 13 of this specification.

12.10 Response Indicator

12.10.1 If specified in the data sheet, response indicators shall be provided suitable for wall/ceiling mounting. Response indicator shall be provided where the detector is located either above false ceiling or below false floor or where detectors are not directly visible. The response indicators shall be connected to the detectors directly and shall be complete with terminal blocks suitable to accept cables with up to 1.5mm² copper conductor. In the normal state of detector, the LEO shall flicker, but in the event the detector goes into alarm condition, the LEO shall glow steadily. LEOs shall be red in colour with 5mm dia. as a minimum.

12.10.2 Use of Response indicators in addressable system is not envisaged unless otherwise specified in data sheet.

12.11 Exit Signs

12.11.1 Exit signs shall be fabricated out of 1.6mm thick cold rolled sheet steel. This shall be suitable for wall mounting or suspension from ceiling. Exit signs suspended from the ceiling shall have text/direction printed on both the side of exit sign.

12.11.2 Fire exit shall be displayed by means of 5mm dia LEOs or backlit text. It shall be powered from the fire alarm panel. Exit sign shall operate on DC power supply 12.11.3. The exit sign shall be either in red letters on white background or white letters on green background.

12.11.4 Where specified in data sheet, self-luminous exit sign shall be provided.

12.12 Hooters

12.12.1 The unit shall consist of solid-state circuitry on a printed circuit board, a loudspeaker and a flashing lamp housed in a weatherproof dust tight, wall mounting type enclosure. The hooter shall, at least, have 102 db (A) output measured at 1-meter distance. The unit shall be powered from the fire alarm panel and operate on DC power. In the event of fire, the hooter shall raise pulsating audio alarm and the lamp shall start flashing.
12.12.2 HAB shall be provided at exit doors of buildings to mute the hooters after evacuation.

12.13 **Flashing Lights (Beacon)**

12.13.1 The unit shall consist of solid-state circuitry on a printed circuit board and a red-capped incandescent lamp and audio unit housed in a dust tight, wall/ceiling mounting type enclosure. It shall derive power from the DGFAP ZFAP and shall operate on DC supply.

12.13.2 Flashing lights shall be installed in the enclosed areas where clean agent/CO₂ is to be released.

In the event a signal for clean agent/CO₂ release is given, the lamp shall start blinking with a warning sound enabling operating personnel to evacuate the area. The audio unit (hooter) shall have 102 db (A) output measured at 1-meter distance.

12.14 **Clean Agent / CO₂ Release and Inhibit Switches**

12.14.1 This unit is required to be provided at the exit of the protected buildings/rooms. If specified, this unit is integrated with DGFAP ZFAP. This shall consist of pull type release and inhibit switches clean agent /CO₂. The unit shall be fabricated out of 2mm thick cold rolled sheet steel suitable for wall mounting. Switches shall be pulled to release or inhibit clean agent /CO₂. Release switches shall have inscription:

"PULL TO RELEASE CLEAN AGENT / CO₂"

And inhibit switches shall have inscription:

"PULL TO INHIBIT CLEAN AGENT / CO₂"

12.15 **Zener Barrier**

12.15.1 Preferably flameproof (Ex'd') equipment that does not require the use of Zener barrier shall be used. When necessary, intrinsically safe (Ex 'i') detectors and MCPs, Zener barriers shall be provided. These shall be located in unclassified/non-hazardous areas.

12.15.2 Normally not more than 10 detectors shall be connected to one zener barrier. However vendor shall indicate maximum number of detectors/ MCPs that can be connected to one Zener barrier without compromising on working of loop/zone. Vendor shall also indicate the maximum loop length from zener barrier considering 1.5 mm² copper conductor, screened cable.

12.15.3 In case loop length permits, zener barrier shall be located at DGFAP itself else it shall be located in safe area nearest to the detector/ MCP.

12.15.4 Wherever zener barriers are provided in safe area outside the Zonal panel or DGFAP, these shall be housed in their own enclosure with IP-55 degree of protection as a minimum.

12.16 **Fault Isolator**

12.16.1 Fault isolator shall be installed, if specified in the data sheet.
12.16.2 Fault isolator shall be designed to provide short circuit protection to an addressable detector loop. It shall be possible to wire the fault isolator at any point in the detector loop.

12.16.3 On occurrence of a fault (short circuit), the isolator shall cut power to all devices installed between the two isolators minimizing the outage of all the detectors in a loop.

12.16.4 The fault isolator shall have the capability to continuously check the faulted side of the loop to determine if the fault still exists. On rectification of the fault, the isolator shall automatically reset itself.

12.16.5 Fault isolator modules shall be housed in an enclosure having IP-55 degree of protection as a minimum. If located in hazardous area, it shall also be tested and approved for use in area classification defined in the data sheet.

12.17 Sirens

12.17.1 Sirens shall be industrial type with minimum 2.5 km unidirectional range (i.e. 5km diametrical range) against the wind direction.

12.17.2 The decibel level of the siren shall, at least be 132 db(A) at 1 meter, to meet the audibility requirement for the above range. Unless otherwise specified, Sirens shall operate at 415 V, 3 ph. AC supply. Sirens shall be housed in weatherproof enclosure. Starter shall be DOL and shall be housed in a separate IP55 enclosure suitable for installation indoor/ outdoor.

12.17.3 For three-phase siren, wall-mounting type three-phase DOL starter shall be supplied. Starter shall be mounted indoor in a building where siren is located. The supply to the siren starter shall be provided by purchaser from Normal or Emergency power source as defined in the data sheet.

13.0 FIELD DEVICES FOR HAZARDOUS AREA

13.1 Hazardous area is classified as Zone 1/ Zone 2, gas group IIA/ IIB or IIC, temperature class T3 (200 DC) as specified in data sheet. The field devices shall be suitable for installation in hazardous area as per specified area classification.

13.2 Field devices such as detectors, MCPs, fault isolators, Beacons, hooters etc for use in hazardous area, if specified in the data sheet shall have flame proof enclosure conforming to IS 2148. All equipment for hazardous area installation shall be complete with flame proof, weather proof cable glands as specified in clause 11.5.

13.3 Equipment, which cannot have flameproof construction, shall be intrinsically safe in design and shall be used with Zener barriers located in safe area.

13.4 Equipment that are tested / certified by a recognized test laboratory of country of origin shall only be offered. The vendor shall possess valid test certificate issued by a recognized independent test house such as CMRI/ BASEEFA/ UL/ FM or Equivalent for the offered equipment.

13.5 All equipment (indigenous or imported) shall have valid statutory approval as applicable for the specified hazardous location from CCE or any other applicable statutory authority.
All indigenous flameproof equipment shall also have valid BIS license and corresponding marking as required by statutory authority.

13.6 A separate name plate shall also be provided on each equipment to indicate details of testing agency, test certificate number with date, statutory approval number with date, approval agency, BIS license number with date, applicable gas group, temperature class etc. The nameplate shall be riveted/ fixed with screws and not pasted. In case above information are embossed on the enclosure, the same need not be repeated.

14.0 ENGINEERING REQUIREMENTS

Unless specified otherwise, vendor shall design entire fire alarm system including design of system architecture with details of integration, cabling requirement and protocol selection etc. Vendor's scope shall also include basic design and preparation of layouts for fire alarm system for plant/ buildings as specified in the data sheet/ purchase documents.

14.1 Conventional Fire Alarm System

i. For conventional fire alarm system, purchaser shall provide typical block diagram. On this basis, vendor shall prepare detailed drawing giving various system component details. The design and engineering shall include sizing and selection of various equipment such as fire alarm panels, batteries, battery chargers, field equipments, siren/ siren starter etc. including preparation of G.A. drawings of various equipment.

ii. The layout engineering for buildings shall include the drawings showing location of MCP/ Detector and other field devices, cable schedules, interconnection diagram, equipment installation drawings etc as minimum.

14.2 Addressable Fire Alarm System

i. Vendor shall develop a system architecture based on purchaser's requirement showing details of various network elements such as DGFAP, CFAP, Work station, networking hardware, redundancy, protocols, data highway etc. including the maximum permissible loop length and length of data highway.

ii. The design and engineering shall include sizing and selection of various equipment such as fire alarm panels, batteries, battery chargers, field equipments, siren/ siren starter etc. including preparation of G.A. drawings of various equipment.

iii. The layout engineering for buildings shall include the drawings showing location of MCP/ Detector and other field devices, cable schedules, interconnection diagram, equipment installation drawings etc. as minimum.

iv. The parameterization facilities of various field devices along with the geographic mimic, annunciation, text messages etc shall be available on the fire alarm panel.

15.0 INSPECTION, TESTING AND ACCEPTANCE

15.1 All the equipment shall be tested to the defined specifications as per mutually agreed test plan/ FAT procedure, which shall be submitted and got approved from Purchaser at least one month before inspection. PMC/ Purchaser's inspectors shall witness all the tests.
15.2 During manufacture, the equipment shall be subject to inspection as per attached inspection plan to assess the progress of work and to ascertain that the quality controls are being maintained. Vendor shall provide all necessary assistance and information concerning the supply to PDIL/Purchaser's inspectors.

15.3 Tests shall be carried out at the vendor's works under his care and expense and Purchaser shall be informed at least 4 weeks in advance regarding this.

15.4 FAT shall include simulation of operational field conditions and test for functional adequacy. Besides all routine, and acceptance tests specified by applicable codes and standards, shall be performed on the complete system.

15.5 For bought out items, the routine and acceptance tests shall be conducted at the respective equipment manufacturer's works.

15.6 At the time of inspection, vendor shall produce original of all the type test certificates, test and approval certificates for hazardous area equipment from testing and approving authority and any other certificates as required from statutory authority for the review of inspectors.

15.7 Vendor shall submit a SAT procedure for PMC/ Purchaser's approval. All equipment and systems shall be tested at site as per the approved SAT procedure.

15.8 SAT shall be conducted by vendor after the entire fire alarm system is installed and interconnected by cables. These tests shall establish the operational correctness of the system. Vendor shall rectify deficiencies noticed during SAT with no commercial implication to Purchaser including replacement of system components and supply of new component for making system successfully operational.

16.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight' etc., shall be clearly marked on the package together with Tag nos., Purchase order Nos. etc. The equipment may be stored outdoors for long periods before erection. The packing shall be completely suitable for outdoor storage in areas with heavy rains/ high ambient temperature.

17.0 INSTALLATION AND COMMISSIONING

Where installation of the system is included in the scope of the vendor, vendor shall arrange all necessary manpower and equipment required for the same. Commissioning of the complete system is to be carried out by vendor in all cases irrespective of whether the installation was performed by vendor or not. All tools, test equipment etc. for the successful commissioning of the system shall be arranged by the vendor. Only the cabling specifically excluded from vendor's scope shall be installed by others. However, termination at panels for purchaser's cables shall be done by the vendor.

18.0 TRAINING

The vendor shall provide, free of cost, comprehensive training to Purchaser's personnel on various operation and maintenance aspects of the Fire Alarm system as agreed during ordering.
<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>BY CONTRACTOR</th>
<th>BY OTHERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0  All Engineering.</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2.0  Design, sizing, selection (type and material) etc. for instruments as per project requirement</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3.0  Detailed engineering, procurement &amp; supply of:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Instruments as per project requirements</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>b) Complete hardware and software necessary to meet project requirements for all system oriented items defined in the package.</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>c) Control systems like DCS / PLC / FF / HART / IAMS / AIMS System Analyzer system, Gas detection system, CCTV, Steam Governor Control, Machine Monitoring System, etc. within this package</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>d) Integration of Control systems like DCS / PLC / Analyzer system, Gas detection system, CCTV, Giant screen, Machine Monitoring System etc. for all the units as defined in this package</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>4.0  Installation of:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) All instruments &amp; accessories in Contractor's scope of supply</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>b) sub packaged instruments, panels and other accessories</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>c) All systems oriented items like DCS / PLC / FF / HART / IAMS / AIMS System Analyzer system, Gas detection system, Machine Monitoring System, etc. located in the Satellite Rack Room and Refinery-III Control room etc. in contractor’s scope.</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>d) All instruments installation accessories</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>e) Gas Detectors</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>f) CCTV</td>
<td>X( Note-1a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>X</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>5.0</td>
<td>a) Provision of instrument road crossings (IRCs), culverts, trench, ducts, trays and their supporting structures as applicable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Cable trenching wherever necessary including cable laying and back filling etc.</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>c) Branch/link Cable tray from main trunk duct/tray in cable cellar up to the respective cabinets in control room</td>
<td>X</td>
</tr>
<tr>
<td>6.0</td>
<td>Laying of all type of cables including special cables, system cables, fiber optical cables with adequate protection</td>
<td>X</td>
</tr>
<tr>
<td>7.0</td>
<td>Provision of various power supplies and their distribution to various locations for</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) DCS &amp; PLC Package (including all sub-systems like FF / HART / IAMS / CCTV / MMS &amp; others)</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>b) Instruments and their accessories</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>c) Sub package items</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>d) All system oriented items in contractor’s scope.</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>e) Analyzer shelters</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>f) Field instruments requiring power</td>
<td>X</td>
</tr>
<tr>
<td>8.0</td>
<td>Earthling system for complete field instrumentation and its integration with main plant Earthling system as required</td>
<td>X</td>
</tr>
<tr>
<td>9.0</td>
<td>Instrument air and its distribution within the unit as required</td>
<td>X</td>
</tr>
<tr>
<td>10.0</td>
<td>Steam tracing/electrical tracing as applicable and insulation</td>
<td>X</td>
</tr>
<tr>
<td>11.0</td>
<td>Painting of instruments, impulse lines etc.</td>
<td>X</td>
</tr>
<tr>
<td>12.0</td>
<td>Provision of various utilities and their distribution as</td>
<td>X(Note-3)</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>13.0</td>
<td>DCS/PLC</td>
<td></td>
</tr>
<tr>
<td>13.1</td>
<td>Supply of DCS/PLC hardware cabinets and software implementation.</td>
<td></td>
</tr>
<tr>
<td>13.2</td>
<td>Preparation of engineering drawings and documents</td>
<td></td>
</tr>
<tr>
<td>13.3</td>
<td>Review of DCS vendor’s drawings/documents</td>
<td></td>
</tr>
<tr>
<td>13.4</td>
<td>Participation in kick-off meetings, system software definition meeting and any coordination meetings at DCS/PLC vendor’s works/owner/PMC/other contractor's office.</td>
<td></td>
</tr>
<tr>
<td>13.5</td>
<td>Participation in Factory Acceptance Test (FAT) at DCS/PLC vendor’s works.</td>
<td></td>
</tr>
<tr>
<td>13.6</td>
<td>Installation of DCS/PLC system at Main control rooms, termination, Glanding termination &amp; ferruling at control room end</td>
<td></td>
</tr>
<tr>
<td>13.7</td>
<td>Loop checking, testing and commissioning, interlock simulation check.</td>
<td></td>
</tr>
<tr>
<td>13.8</td>
<td>PSA Dry Run Test (if applicable)</td>
<td></td>
</tr>
<tr>
<td>14.0</td>
<td>Shop testing, calibration, factory acceptance test /integrated testing as applicable</td>
<td></td>
</tr>
<tr>
<td>15.0</td>
<td>Field testing, calibration, loop checking, commissioning and site acceptance</td>
<td></td>
</tr>
<tr>
<td>16.0</td>
<td>Coordination with various vendors/ other field contractors/ Manufacturers/ Package vendors/ owner/PMC/ licensor etc</td>
<td></td>
</tr>
<tr>
<td>17.0</td>
<td>Ensuring the availability of suppliers specialists services for all system oriented items and special instruments like all analyzers, Ultrasonic flow meters, and Special control valves, any other special instruments etc. during start-up and commissioning.</td>
<td></td>
</tr>
<tr>
<td>18.0</td>
<td>Documentation as per project requirements commissioning and site acceptance</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>19.0 Training</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>20.0 Spares and spare parts (all types)</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1. a) Installation of CCTV cameras and accessories with suitable poles etc. and laying of cables up to Main control room is in the contractor's scope. All the necessary hardware and software required for this shall be in contractor scope.

3. Utilities shall be supplied at battery limit as specified in the process package. Contractor shall be completely responsible for distribution of the same and provision of any other utility required by contractor.
<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>SUPPLY</th>
<th>INSTALLATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0 Instruments</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 All field mounted instruments</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>1.2 All skid mounted instruments</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>1.3 Local gauge board mounted instruments</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>1.4 Local panel mounted instruments</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>1.5 Remote panel/console/cabinet mounted instruments (as applicable)</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>1.6 Analyzers - local or analyzer shelter/analyzer room mounted</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td><strong>2.0 Panels/gauge boards/cabinets (as applicable)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Local gauge boards</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>2.2 Local panels for</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Process units sub-packages as applicable</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>2.3 Remote panels for</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Package units &amp; sub-packages items</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>b) Any other item</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>2.4 System cabinets and accessories for systems engineering supplied by contractor i.e. Machine Monitoring, Steam Governor control etc.</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td><strong>3.0 Special instruments and system oriented items</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 Distributed control system and interface to existing</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>SUPPLY</td>
<td>INSTALLATION</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>----------------</td>
<td>--------------</td>
</tr>
<tr>
<td>system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2 Programmable logic controllers</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>3.3 CCTV alongwith cables upto main control room and hooking upto existing system</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>3.4 Hart &amp; FF maintenance system &amp; Instrument Asset Management System</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>3.5 Alarm Information Management System (AIMS)</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>3.6 Vibration &amp; Machine monitoring system and interface to Refinery-III MMS (system-1) system,</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>3.7 Analyzer &amp; Analyser Systems</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>3.8 Analyzer shelters as applicable.</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>3.9 Gas detection system</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>3.10 GPS Mater clock and time synchronization of DCS/PLC/HART/FF/IAMS/AIMS/VMS/PSA PLC Systems.</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>3.10 Any other special instrumentation item specified in the package.</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
</tbody>
</table>

4.0 Junction boxes

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>SUPPLY</th>
<th>INSTALLATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 For interconnection between field and local panels</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>4.2 For interconnection between field and local panels</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>4.3 Separate junction box for</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>a) For 4-20mA dc signals (separate JBs for intrinsic safe</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>SUPPLY</td>
<td>INSTALLATION</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>----------</td>
<td>--------------</td>
</tr>
<tr>
<td>and non- intrinsic safe)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) For Thermocouple signals</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>c) For RTD signals</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>d) For contact signals</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>e) For Interlock and shutdown signals</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>f) FF Signals</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>g) For power supply to various instruments</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>h) For any other signal not covered but required for completion of job</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
</tbody>
</table>

5.0 Cables

<p>| 5.1 Between field instruments and junction boxes/ local panel               | By Contractor | By Contractor |
| 5.2 Between junction boxes and local panel                                 | By Contractor | By Contractor |
| 5.3 Between local panel and Control Room                                  | By Contractor | By Contractor |
| 5.4 Between analyzer shelters and Control Room.                           | By Contractor | By Contractor |
| 5.5 From field to Control room                                            | By Contractor | By Contractor |
| 5.5 From Control to Other Control rooms                                   | By Contractor | By Contractor |
| 5.6 Between Substation/MCC and Local panel/analyzer shelters/ Control Room.| By Contractor | By Contractor |
| 5.7 Between Substation/MCC and field Power distribution panel/instruments.| By Contractor | By Contractor |
| 5.8 Vibration &amp; Machine Monitoring, analyzer system and Gas detection system cables. | By Contractor | By Contractor |</p>
<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>SUPPLY</th>
<th>INSTALLATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) From field to Control Room</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>b) Within Control Room</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>5.9 CCTV cable from field, field to control room.</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>5.10 Any other cable not covered but required for completion of job.</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td><strong>6.0 Installation materials</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1 Impulse tubing piping, tube/pipe fillings, valves and valve manifolds,</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>steam traps etc. as required.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.2 Instrument air valves, pipes and fillings</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>6.3 Cable trays, cable duct, cable glands and accessories</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>6.4 Instrument stanchions, supports, canopies / Sunshields, supports for</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>cable tray/duct, all consumables.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>**7.0 MCT blocks &amp; frames for cable entry in Main control room/ analyzer</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>shelters/analyzer room. Sealing using Sealing compound is not acceptable</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>8.0 Earthling system</strong> for field instrumentation including earthling</td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>strips, earthling cable, earthling electrode and earthling pit</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>9.0 Power Supply Distribution</strong></td>
<td>By Contractor</td>
<td>By Contractor</td>
</tr>
<tr>
<td>10.0 Special tools and tackles</td>
<td>By Contractor</td>
<td>-</td>
</tr>
<tr>
<td>11.0 Spares and spare parts</td>
<td>By Contractor</td>
<td>-</td>
</tr>
<tr>
<td>12.0 Training</td>
<td>By Contractor</td>
<td>-</td>
</tr>
<tr>
<td>13.0 Documentation as per this package</td>
<td>By Contractor</td>
<td>-</td>
</tr>
<tr>
<td>14.0 Ensuring the availability of supplier’s specialists services for all</td>
<td>By Contractor</td>
<td>-</td>
</tr>
<tr>
<td>system oriented items like DCS, PLC, Gas detection system, Machine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>monitoring system (MMS), analyzers, special instrument etc. during start-up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>SUPPLY</td>
<td>INSTALLATION</td>
</tr>
<tr>
<td>-------------</td>
<td>--------</td>
<td>--------------</td>
</tr>
<tr>
<td>and commissioning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.0 Coordination with various vendors/ other field contractors/ manufacturers/ package vendor/ owner/ Consultant/ licensor etc</td>
<td>By Contractor</td>
<td>-</td>
</tr>
</tbody>
</table>

those items which are not mentioned here but required to fulfill the job requirements shall also be in scope of LSTK Contractor
TRAINING REQUIREMENT

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>07.03.2011</td>
<td>07.03.2011</td>
<td>For Tender</td>
<td>SKPradhan /HSaini</td>
<td>SanjayKrTripathi</td>
<td>SanjayKr Tripathi</td>
</tr>
<tr>
<td>REV</td>
<td>REV DATE</td>
<td>EFF DATE</td>
<td>PURPOSE</td>
<td>PREPD</td>
<td>REVWD</td>
<td>APPD</td>
</tr>
</tbody>
</table>
TRAINING REQUIREMENT

LSTK contractor shall arrange training for owner's personnel at vendor works in India. Different type of courses shall be offered for operation/process engineers and operators, instrument maintenance engineers and technician. Vendor shall indicate a detailed proposal for training in the offer. Travel and living expenses of the owner's personnel shall be borne by the Owner.

LSTK vendor to ensure proper and sufficient hardware and software equipment necessary to conduct the training are available at vendor works/site. Also detailed manual covering the entire course details in hard and soft form is provided to each of the trainees.

The instructor-designate shall have minimum of six months of formal class-room instructor experience and must have complete and thorough technical knowledge of the equipment and system supplied including programming, maintenance and operation.

The requirements of training for owner (one group consisting of operators and other group consisting of hardware/software maintenance engineers) in the operational software and diagnostic programs, are set forth herein.

These training is to be provided, if applicable.
<table>
<thead>
<tr>
<th>System</th>
<th>Vendor works in India</th>
<th>Vendor works at Vendor shop out of India</th>
<th>At Site</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Persons</td>
<td>Course Duration (minimum)</td>
<td>No. of Persons</td>
</tr>
<tr>
<td>DCS System (H/W &amp; S/W Maintenance &amp; Engineering)</td>
<td>15</td>
<td>5 days</td>
<td>1</td>
</tr>
<tr>
<td>PLC System (H/W &amp; S/W Maintenance &amp; Engineering)</td>
<td>15</td>
<td>3 days</td>
<td>1</td>
</tr>
<tr>
<td>DCS System –Operations</td>
<td>30</td>
<td>3 days</td>
<td>1</td>
</tr>
<tr>
<td>TURBINE CONTROL SYSTEM – Operation</td>
<td>10</td>
<td>2 days</td>
<td>1</td>
</tr>
<tr>
<td>TURBINE CONTROL SYSTEM – Maintenance &amp; Basic Engineering</td>
<td>10</td>
<td>3 days</td>
<td>1</td>
</tr>
<tr>
<td>IAMS System (including FF / HART Maintenance System)</td>
<td>20</td>
<td>2 days</td>
<td>1</td>
</tr>
<tr>
<td>Machine Monitoring System</td>
<td>7</td>
<td>5 days</td>
<td>1</td>
</tr>
<tr>
<td>Analyser, GC, Mass Spectrometer (each Make &amp; Type)- Operation &amp; Maintenance</td>
<td>7</td>
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<tr>
<td>CCTV System</td>
<td>5</td>
<td>3 days</td>
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LSTK vendor shall also be responsible for any other requirements necessary to train the engineers deputed by owner within a time limit so that they acquire the necessary expertise to operate and maintain the instruments / systems equipments supplied.

Vendors lumpsum quote shall include training at OEM works (India). However vendor shall also furnish unit rate for training at OEM’s works and site for any addition / deletion purpose.
SUPERVISORY CONTROL PANELS, SUPERVISORY CONTROL DESKS, EQUIPMENT PANELS

1.00.00 PANEL AND DESKS

1.01.00 GENERAL REQUIREMENTS

All DDCMIS system modules, power supply components, other control devices (except field mounted sensors/transmitters) and required for completeness of the system shall be housed in cabinets furnished by the Bidder. All equipment and dedicated cabinets required for termination, marshalling and proper interface within Bidder’s system and also with other systems shall also be provided by the Bidder.

The cabinet mounted equipments shall be fully assembled, installed in mounting racks, wired and fully tested as per specification requirements and Purchaser approved drawings in the manufacturing works of a qualified manufacturer prior to shipment to the project site. The Bidder shall ensure that the cabinets are complete and ready for installation before dispatch from manufacturing works. The installation work at project site for these cabinets should only involve connections through multi pair cables from marshalling cabinets (wherever provided) to system cabinets and inter-cabinet/cabinet to UCD/UCP.

The Control cabinets shall house all types of modules / hardware to achieve all functions of Control System including signal conditioning modules, controller modules, I/O modules, communication controller modules and all other requisite hardware for a complete system.

1.02.00 SUPERVISORY CONTROL PANELS AND DESKS

1.02.01 Control Desks

Supervisory control desks shall be supplied for mounting 6 no.s of works stations and keyboards. Also control desk will be provided for balance work stations – located in computer room, supervisor room etc. All furniture including chairs and tables for printers etc. shall also be provided by the bidder.

Care shall be taken to ensure ergonomically aspects so as to create ergonomically ideal work place considering physical aspects such as an average Indian person’s size and reach, physiological aspects such as line of sight and field of vision and cognitive factors such as concentration and perceptivity. Extreme care shall be taken to design the desks with correct angles and dimensions.
Control Desk for programmer's, Maintenance Engineer's & diagnostic OWSs:-

Required numbers of control desks for accommodating programmer's/maintenance engineer's/diagnostic etc shall be supplied. These shall preferably have the same dimension as that of supervisory control desks.

Two sets of Push buttons for (a) acknowledge, (b) reset and (c) lamp test shall be provided by the side of OWS consoles (one set for SG and one set for TG).

**Desks for accommodating printer:**

Adequate number of table/desks/stands for accommodating printers in bidder's scope shall be supplied. Each printer shall be on a separate table / stand.

**Supervisory Panel Unit Control Panel**

The Unit Control Panel shall be provided to accommodate instruments such as Annunciation windows, PB Stations, A/M stations, Indicators, switches, EWLI, etc and backup consoles for BTG integral control to be mounted on mosaic portion, which are required for emergency operation.

(Exact service will be worked out during detailed engineering)

**1.03.00 TERMINATION CABINETS**

Termination cabinets for the system shall be supplied for terminating all cables originating from the field and for distributing the signals to different functional panels and cubicles.

Incoming cables from the field shall be terminated in suitable terminal blocks in logical sequence.

Prefabricated cables with plug in connectors at both ends shall be used for extending the signals to the functional panels. Matching plug sockets shall be provided in the termination cabinets for terminating the plugs.

The cabinet shall have internal illumination lighting fixtures.

Terminal blocks shall be located inside the cabinets on support wings fabricated of metal plates.

The plug socket shall be mounted on hinged plates to provide an access to the rear pins of the plugs.

General features of termination cabinets and accessories shall conform to the general design and construction specification of panels. Terminal blocks shall be WAGO, Phoenix make.
1.04.00 CONSTRUCTIONAL FEATURES OF PANELS, CUBICLES & ENCLOSURES

All panels, cubicles, consoles and enclosures furnished as per this specification shall be of free standing type and shall be constructed of specified gauge of steel plates. The panel sheet thickness shall be not less than 2 mm unless otherwise specified herein.

The panels, consoles/desks shall be reinforced as required to ensure true surfaces and adequate support for instruments mounted thereon. All instrument cutouts, mounting studs, and support brackets shall be accurately located. All welds on the exposed panel surfaces shall be ground smooth. Finished panel surfaces shall be free from waves, bellies, or other imperfections. Unless specified, otherwise, panel doors shall be hinged and shall have turned back edges and additional bracing where required to ensure rigidity. Door hinges shall be of the concealed type. Door latches shall be of the three-point type to ensure tight closing. Door locks shall be furnished which will allow actuation of all locks by a single master key. All panels shall have removable lifting eyebolts for safe lifting from top during storage and installation handling.

Cabinet doors shall be hinged and shall have turned back edges and additional braking where required ensuring rigidity. Hinges shall be of concealed type. Door latches shall be of three-point type to assure tight closing. Detachable lifting eyes or angles shall be furnished at the top of each separately shipped section and all necessary provisions shall be made to facilitate handling without damage. Front and rear doors shall be provided with locking arrangements with a master key for all cabinets. If width of a cabinet is more than 800 mm, double doors shall be provided.

All panels shall be mounted on vibration dampers, which are secured to channels mounted on the floor. The channels shall be field welded to steel plates set into the concrete flooring. The steel plates shall be located such as to approximate the outline of panel bases. The exact mounting details shall be as approved by the owner during detailed engineering stage. All panels shall be provided with adequate ventilation and packaging density of components shall be restricted so as to limit the temperature rise above ambient to 10°C under the worst conditions. All panels shall have auto on/off switch for internal lighting.

Exhaust Fans with louvers & filters shall be provided in all consoles and panels.

All the panels shall be equipped with Anti vibration pad of min. 15 mm size.

Doors shall be provided with neoprene gasket only.
**1.05.00 SURFACE PREPARATION AND PAINTING**

All panel exterior steel surfaces shall be ground smooth, and painted as specified below:

Suitable filler shall be applied to all pits, blemishes and voids in the surfaces. The filler shall be sand blasted so that surfaces are level and flat, corners are smooth and even. Exposed raw metal edges shall be ground burr free. The entire panel surface shall be sand blasted to remove rust and scale and all other residue due to the fabrication operation. Oil grease and salts etc. shall be removed from the panels by one or more solvent cleaning methods. Alternatively 7 tank process shall be followed.

Two spray coats of inhibitive epoxy primer – surface shall be applied to all exterior and interior surfaces, each coat of primer surfacer shall be of dry film thickness of 1.5 mil. A minimum of two spray coats of final finish colour (Catalysed epoxy finish) shall be applied to all surfaces of dry film thickness 2.0 mil. The finish colours for exterior and interior surfaces shall conform to the following shades:

a) Exterior - RAL 7032.

b) Interior - Glossy white two coats with fire resistant paint

Paint films, which show sags, checks, blisters teardrops, fat edges or other painting imperfections shall not be acceptable and if any such defects appear, they shall be repaired by and at the expenses of the Bidder.

**1.06.00 PANEL WIRING**

Interconnecting wiring shall be provided between all electrical devices mounted in the panels, and between the devices and terminal blocks if the devices are to be connected to equipment outside the panels. The Bidder shall install jumpers between terminal blocks as indicated on the Owner’s schematic diagrams. All alarm contacts located within a panel shall be wired to terminal blocks. Thermocouple and other special circuits shall be field wires direct to instrument terminal blocks without the use of panel wiring.

All control and instrument wiring used within the panels shall confirm to NEC and NEMA standards and shall be factory installed and tested at the works of a qualified manufacturer. All interior wiring shall be installed neatly and carefully, and shall be terminated at suitable terminal blocks. Sufficient clearance shall be provided for all control and instrumentation leads, and all incoming and outgoing leads shall be connected to terminal blocks suitably located for connecting external circuits. The arrangements for circuits and terminal blocks shall agree with schematic diagrams furnished by the Owner/Technical Specialist. All panel wiring shall have appropriate ferruling.
for clear identification. Interior wiring shall be so arranged that the external connections can be made with only one wire per terminal point. Any common connections shall be made internal side of the terminal blocks. Common connections shall be limited to two wires per terminal. Instrumentation cable shield wires shall be connected to separate terminal at the terminal block.

Signal circuit shields shall be grounded at the power supply end only or as recommended by manufacturer.

All internal wiring (except low level instrument wiring) shall be National Electric Code Type SIS, Polymeric/Elastomeric insulated, 1.5mm² tinned copper stranded conductor, switchboard wire, or owner approved equal.

Panel wiring shall have a flame resistant insulation with adequately sized copper conductor based on current carrying capacities as etc forth by the National Electric Code.

Wire sizes shall be as specified herein and suitable for intended applications.

Wiring to door mounted devices shall be provided with (49 strand minimum) adequate loop lengths of hinge wire so that multiple door openings will not cause fatigue braking of the conductor.

Wiring shall be arranged to enable instruments or devices to be removed and/or serviced without unduly disturbing the wiring. No wire shall be routed cross the face or rear of any device in a manner, which will impede the opening of covers or obstruct access to leads, terminals or devices.

Panel wires shall be identified with wire number and each termination by means of Action craft products split sleeve or Borden Chemical Co. indelible tubing markers or owner approved equal. Corrections and modifications of all panel wiring shall be Bidder’s sole responsibility. Any corrections/modifications required at site for successful commissioning shall be done by the Bidder without any additional costs. Terminal lugs furnished must be of the compression, insulated sleeve, half ring tongue type. Open-ended terminal lugs will not be accepted. Wires shall not be looped around the terminal screws or studs.

Wires shall not be tapped or spliced between terminal points.

Panels, cabinets, consoles/desks will be provided with removable, gasketed cable gland plates and cable glands, for all floor slots used for cable entrance. Split type grommets shall be used for prefab cables.

Internal wiring in factory prewired electronic systems cabinets may be installed according to the Bidder’s standard as to wire size, insulation, and method of termination on internal equipment except that insulation for all wiring power supply wiring, and interconnecting cables between devices shall pass the following tests.

a) Flammability test IEEE 383/1974
b) When tested under UITPP test method or ASTM 2893/77 light transmittance of 80%
c) When tested under IEC 754-1 maximum acid gas generation shall be 2% by weight
d) Oxygen index not less than 30 as per ASTM D 2863.

All terminations for intra panel wiring inter panel cabling and connecting the Bidders panels, PB stations, control stations etc. shall be with Wago / Screwed connections. Soldered connections are not acceptable. All field side or external input connections shall also preferably of Wago / Screwed connection.

Identification of conductors may be done by insulation colour coding identified on drawings or by printed wiring lists. Terminal blocks for connection of external circuits in to factory prewired electronic system cabinets shall meet all the requirements as described elsewhere in the specification. For all multicore cables, the outer sheath shall satisfy the properties identified above. However, for panel wiring, the wiring insulation shall also satisfy the properties identified above. The internal wiring shall be done in coloured wiring.

1.07.00 INSTRUMENTS MOUNTING

1.07.01 Instruments and relays mounted on the panels shall be easily accessible for repair and replacement without disturbing other equipment their connected wiring. No special tools shall be needed for the purpose.

1.01.00 PANEL ILLUMINATION

Panels shall be provided with fluorescent illuminating lamps with door switch and three (3) point 15A, 240V AC sockets with switch for maintenance purposes. These switches shall be with quick make and break mechanism.

1.09.00 FUSE BLOCKS

Where fuse blocks rated 30 amp., 250 Volts are required by the specifications or the manufacturer’s design, they shall be modular type with bakelite frame and reinforced retaining clips. Blocks shall be class H.2 pole, screw terminal fuse blocks. Blocks for other current and voltage ratings shall be similar in construction.

8.10.00 FUSES

All fuses shall be fast acting semiconductor types for AC supply and compatible to the UPS fuses. For all DC Powered devices, similarly the fuses shall be fast acting compatible to DCDB fuse provisions.

8.11.00 MOULDED CASE CIRCUIT BREAKERS
Moulded case circuit breakers used in equipment covered under these specifications shall have not less than 5000 amp. Interrupting capacity at 220 Volts DC 10,000 Amp. Symmetrical interrupting capacity at 240 Volts AC.

8.12.00 GROUNDING
All panels and cabinets shall be provided with a continuous bare copper ground bus of minimum 6 mm x 12 mm cross section. The ground bus shall be bolted to the panel structure and effectively ground the entire structure. Each Ground bus shall have provision at each end for connection of ground leaks (6 mm x 50 mm GI Flats) by suitable bolting. All system cabinets shall be brought to a common system ground by the bidder.

Each circuit requiring grounding shall be individually and directly connected to the panel ground bus by ring tongue type compression lugs. For electronic system cabinets the system ground bus shall be insulated from the cabinet enclosure and shall be separately connected to the system ground. All system cabinets shall be brought to a common system ground by the bidder.

The Bidder shall furnish his recommendations regarding grounding requirements for all equipment/systems and shall specifically indicate the deviations if any from the above requirements as a part of his proposal.

8.13.00 TERMINAL BLOCKS
For all inputs to the system emanating from the field or other systems, the bidder shall furnish terminals suitable for correct size of field cables.

8.13.01 Screw Type Terminal Block shall be as per IEC-60947-7-1 and should be made of unbreakable Polyamide 6.6 meeting V0/V2 class acc. To UL94. All metal parts including screw should be made of copper alloy and non-ferrous nature in nature. Its screw should be captive and shall have screw locking design to prevent loosening of conductor up to Vibration level of 5G. the wire shall be terminated through hollow pin type standard lug. Cage-Clamp (Spring Type) Terminal Block shall have spring made of high grade steel with front entry and suitable for wir termination with standard lug. Screw-less TB shall have two slots for shorting/ testing with clear marking provisions at centre and both sides. Both TB’s shall comply to latest ATEX and RoHS standards. Preferable makes are Phoenix contact, Wago and Weidmuller.

8.13.02 Terminal blocks shall be provided with white marking strips and re permitted by the safety codes and standards shall be without covers.

8.13.03 Fuses shall not be mounted on terminal blocks. Neither step type terminal blocks nor angle mounting of terminal blocks will be acceptable.

8.13.04 At least 25 per cent spare unused terminals shall be provided on each terminal block for circuit modifications and for termination of all conductors in a multi-conductor control cable.

8.13.05 220V AC/DC for powering the solenoids should be through terminal with fuse protection.

8.14.00 NAME PLATES AND LABELS
Name plates of adequate size shall be provided for each panel on front and rear of the panel. Instruments/other accessories mounted inside the panels shall have identification marking clearly visible from inside.

Devices to be mounted on the panels shall also be labeled on the panels shall also be labeled on the outside of the panel. Name plates shall be of phenolic sheets with white letters on black background. Name plates shall be attached to the boards by means of stainless steel panhead screws. Fuses provided for protection of various boxes shall be accessible for replacement. Fuse boxes shall be provided with circuit label and fuse rated current and voltage.

### 8.15.00 Control Room Layout

The control room layout shall be designed in line with guidelines given below. The control room shall be partitioned to different rooms to house the following equipment:

(a) Unit Control Desk (UCD), Printers, Electrical Control Panel (ECP) in the main control room.

(b) The system cabinets, marshalling cabinets and electrical auxiliary cabinets, Electrical panels & SEE panels in the electronic cubicle room.

(c) Maintenance Engineer’s OPERATING STATIONs with keyboards, printers and other peripherals in Maintenance Engineer’s Room.

(d) Uninterrupted Power Supply (i.e., inverters and distribution boards) (UPS) in UPS room.

(e) Lighting shall be designed for maximum comfort and minimisation of OPERATING STATION/LVS glare and shall be adjustable.

(f) Co-ordinated colours and material for floors, walls and ceiling shall be provided.

(g) Room designs shall absorb noise in the control room and engineers/shift supervisor room.

(h) Positively pressurised and filtered air conditioning shall be provided for all control rooms.

(i) Designs and material will be in accordance with NFPA Fire protection for Power/Electric Generating plant.

(j) All control Rooms shall be designed to minimise dust ingress. Air locks shall be provided.

(k) Double Doors and the corridors shall be of sufficient size and layout to allow access of 2750 for equipments.
(l) Fire and Smoke detection equipment shall be located in all ceilings.

(m) Temp. & humidity monitoring system in each control room.

(n) Air Curtains at each entrance to Main Control room.

8.15.01 Item (a) to (d) referred above shall be mounted in an air-conditioned control room having false roof and false flooring. The control room will be partitioned with glass between the following rooms:

(a) Main Control Room and Maintenance Engineer’s Room.

(b) Maintenance Engineer’s Room and Electronic Cubicle Room

(c) Electronic Cubicle Room and UPS Room.

In additions to above following rooms shall be provided at operating floor-

1) Training/Meeting Room/ Conference Room.

2) Equipment Storage Room.

3) C & I Maintenance/laboratory Room.

4) Shift Supervisor room.

5) Documentation Centre for storage for all Plant O & M manuals, control system software backup, & all others operating / maintenance files, logs, records etc.

6) Toilets/refreshing room.

8.16.00 ASSEMBLY AND INSPECTION

As soon as the panel’s fabrication is over, Owner shall inspect the panels and further work on the panels, namely assembly, wiring and assembly of components shall be carried out only after the inspection.

8.17.00 DOCUMENTS TO BE FURNISHED ALONG WITH THE BID

i) Complete B.O.M.

ii) Dimensional drawings of control panel, supervisory control desks and other desks & stands indicating the dimensional details.

iii) General layout drawing of mosaic control panel (front view) indicating general arrangement of equipments and instruments mounted therein.

iv) Filled in data sheets as per section no.13.00.00.
8.11.00 DOCUMENTS TO BE FURNISHED BY BIDDER AFTER THE AWARD OF CONTRACT (DURING DETAILED ENGINEERING)

i) Complete B.O.M.

ii) Dimensional drawings of control panel, supervisory control desks and other desks & stands indicating the dimensional details.

iii) General layout drawing of mosaic control panel (front view) indicating general arrangement of equipments and instruments mounted therein.

iv) Filled in data sheets

8.19.00 ERECTION AND COMMISSIONING

8.19.01 General Requirements

8.19.01.01 The Bidder shall furnish all construction materials tools special wiring and piping accessories, air filter pressure regulators separation chambers, junction boxes compensating cables and all other special devices required for complete installation of all control and instrument equipment furnished under this specification.

8.19.01.02 Detailed installation drawings for each equipment furnished under this specification shall be prepared by the Bidder for Owner's approval. Installation of all equipment/systems furnished by this specification shall be as per Customer/ Consultant approved drawings.

8.19.01.03 The Bidder shall co-ordinate his work with the main equipment suppliers where these instruments and devices are to be installed under these specifications. The bidder shall take responsibility for commissioning of complete control loop(s)/measurement system irrespective of the supply of the primary as well as final control element.

8.19.01.04 Any special tools kits and equipment used by the bidder during commissioning including those not quoted in his offer shall be handed over to the Owner, after commissioning.

8.19.01.05 Erection tools and test kits/instruments offered by the bidder shall be sufficient for testing, commissioning and maintenance of plant. If any additional special tools/test instruments is required/brought by the supplier during testing and commissioning, the same shall also be handed over to the purchaser without price implication.
8.19.01.06 All panels shall be re-painted at the time of handing over.

8.19.02 Codes and Regulations

All erection procedures shall conform with accepted good engineering practice and with all applicable governmental laws, regulations, codes and standards.

8.19.03 Equipment Setting and Location

8.19.03.01 All field mounted instruments and accessories shall be bracket or sub panel mounted on the nearest suitable wall or building column. The brackets, stands, supports and other miscellaneous hardware required for mounting instruments and accessories such as receiver gauges, air filter regulator sets, valve manifold etc. shall be supplied and installed. No field mounted instrument shall be installed such that it depends for support or rigidity on the impulse piping or on electrical connection to it.

8.19.03.02 Indicating type field mounted instruments shall be installed in such a way that centre of indicating dial shall be about 1600-1800 mm from operating floor level. Non-indicating type field instruments shall be installed such that operating handle of that instrument comes within 1600 mm from operating floor level.

8.19.03.03 All Temperature/Pressure Switches shall be located on a wall or building column and shall be mounted to permit ease of adjustment. The connecting capillary tubing/impulse piping shall be guarded and supported in tubing race way to protect it from damage.

8.19.03.04 All brackets, stands, supports and other miscellaneous hardware required for mounting devices shall be furnished and installed.

8.19.03.05 Any required adapting hardware such as adaptors, nipples, drilled caps etc. shall be provided for complete installation of control devices into process connections.

8.20.00 Specification For Erection Hardware

The erection hardware shall meet the following specifications:
## Impulse Piping

### i) High pressure and high temperature services
- Material: Seamless Alloy Steel
- Piping: to ASTM A335 GR.P22 and furnace region (Medium: Steam & Water)

### ii) Low pressure and low temperature services
- Material: Seamless carbon steel piping to ASTM A106 Gr.B (Medium: Steam & Water)

### iii) Low pressure and low temperature services
- Material: ERW carbon steel piping to IS 1239:1973 Heavy class System (Air, Flue gas & BCW)

### iv) Steam and Water Analysis system
- Material: Seamless stainless steel piping to ASTM A312 GR. TP-321

### v) Seamless copper tubing
- Material: ASTM B-75

## Fittings

### i) Material for socket weld fittings
- Material: ASTM A105 ASTM A182 Gr. F22 6000/3000 lbs

### ii) Dimensions of fittings
- Material: ANSI B16.11

### iii) Fittings for steam and water analysis
- Material: ASTM A182 Gr. F-321

## Valves

### i) 3-way valves
- Material: SS body/Forged CS body stellited internals and SW ends as per requirement for 2500 lb/600 lb ASA ratings.

### ii) 3-valve manifolds
- Material: FAS body/FCS body 316SS stellited internals with
NPT(F) SCRD ends for 2500 lb/1500 lb/600 lb ASA ratings.

iii) 2-valve manifolds
FCS body, 316SS stellited internals, NPT(F) SCRD ends.

iv) Isolation and drain valves
Globe valves with FAS body/FCS body, 316SS stellited internals, SW ends for 2500 lb/1500 lb/600 lb ASA ratings.

8.20.04 Condensation vessels
FAS/FCS body with NPT(F) SCRD connection and vent plugs for 2500/600 lb ASA ratings.

8.20.05 Dust separating chambers
ERW carbon steel pipe to IS-1239 Heavy Class

8.20.06 Racks and Associated Equipment
ANSI C83.9-1972

8.20.07 Code for pressure piping, welding and Hydrostatic testing
ANSI B-31.1

8.20.08 Flexible conduits with fittings
Lead coated, paper insulated, heat resistant flexible metallic conduits with necessary fittings.

8.20.09 Junction Boxes
In general junction boxes shall be designed in accordance with NEC, Article 370, paragraphs 18, 19 and 20 or equivalent standards. Junction boxes for use in outdoor or damp locations shall be of FRP material with IP 65 class protection. The enclosure shall conform to NEMA-4 with hinged door lockable type. Conduit and cable shall enter the lower portion of the box in such a manner that all terminals strips are above conduit entry points. Canopy to be provided where JB's installed in area open to sky.

8.20.10.00 Transmitter Enclosures
8.20.10.01 Transmitter Enclosures shall be free standing, enclosed type offering protection against dust, moisture and vermin. Enclosures shall be suitable for outdoor installations, in thermal Power Plants.

8.20.10.02 Instrument piping inside the enclosure shall conform to the specification and in line with typical installation drawings enclosed with the specification.

8.20.10.03 Blow down header shall be provided inside the enclosure as called for.

8.20.10.04 Bulk head connection shall be provided to receive and terminate the impulse pipes from root valves.

8.20.10.05 Instrument tubing, fittings and isolation, drain valves shall be to ANSI code for pressure piping. Piping/tubing shall be subjected to hydrostatic tests at 1.5 times maximum system pressure.

8.20.10.06 Support angles shall be provided for valve manifolds, wiring trays etc. Enclosures shall be complete with necessary bulk head fittings, junction boxes, drain header and other accessories as needed on the basis of approved hook up drawings.

8.20.10.07 Sufficient spacing among adjacent transmitters shall be maintained to offer easy accessibility and operational convenience. The enclosure shall be designed with sizes to suit the grouping and to completely include all the hardware for hooking up the transmitters to the process on the basis of approved installation diagrams.

8.20.10.08 Wiring and termination practices, painting and finishing of the enclosures shall be as per procedures stipulated under control panels.

8.20.10.09 Hydrostatic tests for piping/tubing and functional checks for correct wiring shall be carried out.

8.20.11 The typical installation drawings are enclosed in Volume-III.

8.20.12 The quality of the erection equipment used for complete instrumentation and control equipment shall meet all the requirements indicated above and quantity shall be on as required basis for the complete control and instrumentation equipment as indicated in this specification. The bidder shall indicate the lumpsum price accordingly.
SUPervisory Control Panels, Supervisory Control DEKS, Equipment Panels

FORM NO: 02-0000-0021F1 REV2
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SECTION VI – 5.3.1
DESIGN PHILOSOPHY – PIPING

PLANT: STEAM GENERATION PLANT

PROJECT: INTEGRATED COAL BASED FERTILISER COMPLEX AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA)
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1.0 SCOPE

The scope of this document is pertaining to the design philosophy, norms and specific requirements which shall be adhered to by LSTK contractor or his associates and representatives during the course of the project in designing, procurement & construction of piping material.

1.1 Applicable Standard & Codes

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2.0 DESIGN PHILOSOPHY

2.1 General

2.1.1 Piping systems shall be in accordance with Clause 1.1, which permits the use of the following specifications:

ASME B31.1 Power Piping

Materials, design, construction, testing and inspection shall be fully in accordance with the selected specification.

2.1.2 The dimensions, manufacturing tolerances and marking of ferrous and non-ferrous piping components shall conform to the applicable standards. The design shall comply with all applicable codes, laws and statutory regulations prevailing in INDIA. The Contractor shall optimize the layout with the approval of the owner and include any changes resulting from HAZOP studies and taking into consideration the following:

i) General site layout taking into account the topographical geo-technical aspect of the site.

ii) Access for maintenance and fire appliances.

iii) The interdependency of units and buildings with each other within the complex.

iv) Safety escape routes for personnel based on emergency or disaster management plans in the event of environmental upset or fire.

v) Suitable drainage system of Project site.

2.1.3 Material of construction shall be suitable for specified process duty (both normal and abnormal operations) and have a projected life and corrosion/erosion allowance in excess of minimum life of the project. Piping materials specified in piping materials specification shall be used for selection of material of construction of major services.

All materials under steam service shall be supplied with proper certificates in prescribed forms as per IBR Act.
3.0 CODES, STANDARDS AND SUPPLEMENTARY SPECIFICATIONS:

3.1 General

3.1.1 The latest edition of codes listed in clause 1.1 shall be applicable for piping system design, materials, fabrication, manufacture, erection, construction and inspection etc. For any item not covered in the list of codes and standards INDIA / International Standards / proven design may be finalized based on discussion with Owner.
   i) Steam generation plant piping as per ASME B 31.1.
   ii) Fire protection system shall be designed and installed in accordance with applicable NFPA (National Fire Protections Associations) Codes.

4.0 GENERAL DESIGN

4.1 Design

4.1.1 Flanges for process and utility piping shall be in accordance with ANSI B16.5 and ANSI B16.47.

4.1.2 Wherever possible all purchased equipment shall be supplied with flanges that comply with ANSI B16.5 & ANSI B16.47.

4.1.3 The minimum size of piping to be used in pipe-racks shall be 2” NB.

4.1.4 With the exception of equipment connections the minimum size of piping shall be ½” NPS.

4.1.5 Pipe sizes 1 ¼”, 2 ½”, 3 ½” and 5” NPS shall not be used except as connections to purchased equipment.

4.1.6 Threaded pipe nipples between headers and vent, drain and instrument isolation valves shall be Schedule 160 for CS and Schedule 80S for SS in the size range ½” to 2” NPS.

4.1.7 Piping 2” NPS and above shall be butt-welded. All weld joints in piping 1½” NPS and below shall be socket welded using socket weld fittings.

4.1.8 In Class 900 and higher pressure rating block and bleed valves shall be used for systems open to atmosphere, such as vents and drains. Piping in hazardous service shall have vents, drains and bleeds routed to a safe location. The same substances shall be vented to the flare system.

4.1.9 When a line of one material specification is connected to a line of higher material specification, the connecting line shall be constructed of the higher material specification or pressure rating up to & including the first block valve.

4.1.10 As a minimum, piping systems shall have isolation facilities as follows:
   Hazardous service and Normal service (Class 900 and above) shall have double block isolation valves with a downstream drop-out spool.
   Normal service (Class 150 to 600) shall have a valve and downstream spectacle blind.
   Generally, equipment shall have provision for isolation of piping to each equipment connection by means of valves and /or blinds as determined by service conditions.
4.1.11 Piping flexibility shall be achieved by the use of piping offsets and expansion loops whenever possible. Expansion joints shall not be used without written permission of the Owner.

5.0 DESIGN PHILOSOPHY / GENERAL CRITERIA

5.1 General Guidelines

All steam generation plant piping will be as per applicable IBR / ASME standards. All piping will be aesthetically and neatly laid on pipe racks with approved colour coding.

Piping design will be as per ASME B 31.1. All piping required for effectively connecting the steam generator with the steam, feed water, and other systems shall be provided. The piping provided shall be complete in all respects including valves, fittings, supports etc. as required. Necessary supporting materials, towers and trestles to support and anchor the pipelines at regular intervals shall be supplied. Suitable expansion loops and hangers shall be provided wherever necessary.

The correct locations of hangers and supports, with as applicable spring stiffness, shall be considered for the flexibility analysis.

Suitable expansion loops restraints and anchors shall be provided so as to ensure compliance with the applicable codes and to limit the stress and reactions to within the allowable values.

All high pressure drain or vent valves or other valves to be provided with one control & one isolating valve set, to prevent any passing of the operating valve.

- Pipe fittings like elbows, equal tees and reducers shall be as given below:
  a) For pipe size 2” NB and above shall be butt welded type.
  b) For 1 1/2” NB and below shall be socket welded type.

- Branch connections:
  a) Socket welding half coupling, as per B16.11, for size 1 1/2” NB and below.
  b) Welded branch connections with proper reinforcements for sizes
above 1 1/2” NB.
All pressure tapping for pressure applications 40 kg/cm² and above shall be of size ¾” NB with two root valves. For pressures 40 kg/cm² and less the size shall be ½” NB with one root valve. All thermo-well boss shall be one(1) inch NPT.

The design of the piping system shall be based on the ANSI B31.1 code. In addition the statutory requirements Flexibility analysis shall be made for all piping systems with operating temperatures above 100ºC. The correct locations of hangers and supports, with as applicable spring stiffness, shall be considered for the flexibility analysis. suitable expansion, loops, restraints and anchors shall be provided so as to ensure compliance with the applicable codes and to limit the stress and reactions to within the allowable values.
Drains at all low points and vents at all high points shall be provided.
All local instruments shall be located on pipelines so as to render them observable from the nearest available platform

5.2     Equipment Layout
5.2.1     Basis of Equipment Layout
Equipment Layout shall be finalized based on the following data :
 a) Plot Plan of Proposed Integrated Coal Based fertilizer Complex ( Dwg. No.-PC009-0000-0001 Sh.01)
b) P&I Ds
c) Equipment Data Sheets
d) Wind Direction
e) Safety Distance and Specific Distance mentioned in Piping Design Basis and as per statutory requirements.

5.2.2     Development of Equipment Layout
The following aspects shall be considered during development of equipment layout.
a) Process Requirement -Proper interconnection between equipment as per P&IDs to achieve the intended process parameters.
b) Economy of piping material- Minimize the quantity of costly piping.
c) Erection & Construction requirements:
Erection scheme and schedule of all equipment must be considered during equipment layout to have smooth erection mainly in case of tall columns, heavy equipments like thick walled reactors, space for laying tall columns, approach roads for cranes / derricks for lifting the column or reactors and requirement of special foundation / pile etc.
d) Operation and Maintenance Requirement
   - Overhead and side clearances for exchangers and pumps
Provision of exchanger’s tube bundle pulling area Horizontal & overhead clearances for easy movement of working personnel.

- Crane approaches for air coolers/fired heaters.
- Provision of catalyst loading/unloading facilities.
- Provision of monorail for pumps and exchangers
- Provision of EOT crane for compressors.
- Provision of operator’s cabin.
- All coke chambers shall be having the lift provision.

e) Similar equipment grouping - All columns, exchangers, pumps etc. should be grouped together for convenience of maintenance and safety wherever feasible.

f) The technological structures should be interconnected for easy movement of operational personnel.

g) U/G piping corridors for main headers should be marked in equipment layout for all underground piping.

5.2.3 Plant Layout & Design guidelines

5.2.3.1 General

The plant layout shall be based on ensuring adequate access, to allow construction, inspection, maintenance and operation to be performed in a safe and efficient manner. The alignment of equipment and pipe shall offer an organized appearance. The layout shall be in accordance with, but not limited to the design practices described in this criteria.

Where dynamic loading, limited pressure drop or other severe service condition applies, particular care shall be taken in routing pipe lines.

Flushing connections shall be provided on all lines containing flammable or toxic material, slurries, and materials which solidify when the line is dead. Sufficient Nitrogen purging points shall also be provided. Supply piping of fuel gas shall be arranged for equal flow distribution.

Trolley beams, pipe davits, shall be provided with appropriate removable hoists mechanism for charging and discharging catalysts, chemicals, packing rings etc.

Piping and all other services shall be arranged so as to permit ready access of Cranes for removal of Equipment for inspection and servicing.

All utility and process piping shall be located above ground, and major lines shall be located in overhead pipe ways.

The following lines may be buried providing they are adequately protected.

i) Cooling Water Lines 18" NB and larger.

ii) Potable Water Lines.

iii) Firewater mains.

iv) Drain and sewer (oily and chemical) lines from catch basin to mains and manholes.

Lines that must be run below grade, and must be periodically inspected or replaced, shall be identified on the P & ID’s; these lines must be placed in covered
concrete trenches. Sleeper-ways shall not be used in process areas where they may block access for personnel and equipment.

Fire protection system shall be designed as per NFPA and as per local law/Civil Defense requirements.

Drip legs and dead ends shall be avoided, especially for piping where solids or fluids may congeal from corrosive condensate.

Where sleeper ways are used the elevations shall be staggered to permit ease of crossing or change of direction at intersections. Flat turns may be used when entire sleeper ways change direction. Flat turns must not be used within pipe racks.

All cooling towers should have sunshades at top distribution decks to avoid algae growth. Cooling towers should be located away from process unit area, preferably downstream direction of wind. Orient the short side of the tower along the prevailing summer wind for maximum efficiency. Locate cooling towers a minimum of 30m away from process units, utility units, fired equipment, and process equipment. All cooling tower inlet headers shall be laid at the bottom of the tower with risers going to the top of individual cells of cooling tower having proper vents.

Spacing and routing of piping shall be such that expanding/contracting lines (including insulation) will not clash with adjacent lines, structures, instruments and electrical equipment during warm up and cool down.

Piping to be sloped shall be indicated on the P&I D’s.

Operator cabins shall be provided for each unit.

5.2.3.2 Pipe-Rack/T-Post/Small Portals

In general, equipment layout shall be prepared considering straight pipe rack, however other shapes like L / T / U / H / Z etc can also be considered based on area available.

The width of the rack shall be 4M, 6M, 8M, 10M or 12M for single bay having four (4) tiers maximum. In general, the spacing between pipe rack portals (span) shall be taken as 8M for main rack. However it can be decreased to 6M depending on the size/number of the pumps to be housed below pipe rack. Intermediate Beams between two portals shall be provided to support smaller pipes <= 2". 20% extra space shall be provided on the pipe rack and portals on each tier for future expansion/modifications. Water lines more than 16" shall not be routed over rack.

- Gap between two tiers of pipe rack shall be minimum 2M.
- Clearance beneath pipe rack shall be 3.8M minimum
- Road clearance shall be 9M minimum wherever heavy duty crane movement is required during construction and future maintenance.
- Road clearance shall be 7.5 M minimum for main roads.
- Road clearance shall be 5M minimum for secondary roads.
- T-Portal's width shall not be more than 2.5 meter and height shall not be less than 3.0 meter.

5.2.3.3 Towers and Vertical Vessels

Towers and vertical vessels shall be arranged in a row with common centre line, decided by the largest vessels, placing O.D. Of the equipment minimum 4M away
from the pipe rack. A minimum clearance of 3M shall be allowed between tower shells, but in any case adjacent towers shall be checked so that platforms do not overlap considering the deflection of towers (deflection of towers shall be considered minimum L/200 MM, WHERE, (L=height of tower). A minimum 100 mm horizontal gap shall also be provided between platforms of adjacent towers after deflection and that a minimum 900mm is left between tower plinths. Also the gap between vertical vessels shall allow full opening of manhole covers without restriction.

Efforts shall be made to provide interconnecting platforms at suitable levels for adjacent towers and/or adjacent technological structure etc., Interconnections where ever feasible shall be done, after taking thermal expansions of towers into consideration.

The maximum vertical distance between platforms shall be 6 m. All level switches, LGs etc including their isolation valves shall be accessible from ladders or platforms. To handle heavy items (like relief valves, blinds etc.), davit of suitable capacity to lift higher weight of safety valves/ Blind/ Internals etc. is needed. The davit shall be on the side of the vessel away from the rack. The area at grade shall be kept clear for a dropout. Davit capacity shall be minimum 1 MT.

Chemical vessels to be located close to the dosing point to the extent possible, especially corrosion inhibitors.

5.2.3.4 Re-boiler

Re-boiler shall be located next to the tower they serve except fired heater type. The elevation of re-boiler shall be as given in the P & ID’s. Horizontal thermo siphon types are usually supported by the tower and are located on the back side to be accessible for maintenance. Large vertical types may require a supporting structure which cannot be supported from the tower/column. Re-boiler piping shall be checked for pressure drop before finalization.

5.2.3.5 Horizontal Vessels

The horizontal vessels shall be laid perpendicular to pipe rack and shall be placed minimum 4M away from the pipe rack. The clearance between horizontal vessel shells shall be minimum 2M or 900 'mm clear aisle whichever is higher.

5.2.3.6 Pumps

Wherever practicable pumps shall be arranged in rows with the centre line of the discharge on a common line. In general, pumps shall be kept inside the pipe rack. However in case of smaller racks, pumps shall be kept on one side or outside the pipe rack to provide clear access under the rack as per clause 5.2.3.11.2.

Pump foundation height shall be 300 mm above H.P.P.

Gap between each pump foundation / and foundation of technical structure should be sufficient for easy removal of equipment after piping. Clearance between two adjacent pumps shall be such that clear 900 mm aisle is available.

All pumps not open to sky with motor rating >= 45 KW shall be provided with monorail. No monorail should normally be provided for pumps outside rack and sufficient space below rack shall be available for pump maintenance.
5.2.3.7 **Exchangers**

In most of the cases floating head of exchangers are placed on a line minimum 4M away from pipe rack. Shell and tube type exchangers may have a removable shell cover with flanged head. Tube pulling or rod cleaning area must be allowed at the channel end. This shall be minimum the tube bundle length + 1.5M from the channel head. In case of vertical exchanger suitable platform shall be provided below the top flange of channel or bonnet.

Minimum clearance in between two horizontal exchangers shall be 2M or 900mm clear aisle whichever is higher.

Likewise Heat Exchanger train should be suitably spaced such that shell/tube inlet/outlet piping do not foul floating Head Covers creating maintenance problem.

Hydro extractor is considered for exchanger bundle/shell removal. Monorails to be provided for tube bundle removal only for exchangers not accessible to Hydro extractor. No special bundle removal arrangement will be provided for exchangers that are open to sky. Davit shall be provided for floating head cover for all exchangers.

5.2.3.8 **Fin Fan Exchangers**

Fin fan exchangers shall be located over the main pipe rack or on technological structure.

15.0 m horizontal distance shall be maintained from furnace/heater. The width of the structure from where Air Fin exchanger assembly is supported shall be minimum 2.0m more than the Air Fin exchanger tube bundle length so that proper supporting of inlet/outlet piping manifolds can be done from the main members of pipe rack/technological structure to transfer piping load to main structural members. Monorail shall be provided at one end of air cooler platform area for lowering the gear boxes.

5.2.3.9 **Furnaces**

Furnaces are located upwind or side wind of process units to blow any combustible leaks away from the open flame. They are located minimum / 90M away from storage tanks and 30M away from control room. Vessels / reactors directly connected to furnace are exception. Furnaces shall be arranged with centerline on a common line in case of circular furnace and wherever a common stack is furnished to cater more than one furnace the stacks shall be located at the end or side which is away from the unit. In case of individual box furnaces, the edge of the furnaces on the rack side shall be matched. F.D. fans shall be located at one corner of furnace area away from equipments handling hydrocarbons. It shall be ensured that there are no working platforms within an elevation of 6.0 M below the tip of stack height inside a 25.0 M radius of the stack. However the stack height shall be governed by statutory authority

For maintenance, vertical tube furnaces must have access to permit a mobile crane to remove and replace tubing. Horizontal tube furnaces must have horizontal free space equal to tube length for tube pulling/maintenance/cleaning.
In case of bottom floor fired heaters, there shall be adequate headroom clearance underneath the furnace for removal of burners. In case of wall fired furnaces minimum 2.0 M wide platform with escape route at each end is necessary.

Pits and trenches are not permitted under furnace or any fired equipment. Underground drain points and manhole covers shall be sealed within furnace vicinity.

APHs should be located in such a way that the modules can be removed by mobile crane.

However, layout of furnaces, ID / FD fans, stacks and APH etc shall be arranged as per final approved vendor data.

### 5.2.3.10 Compressors and their Prime Movers

Two major types of compressors used in process plants:

1. Centrifugal compressors
2. Reciprocating compressors. (Vertical reciprocating compressors for any service are not acceptable).

Compressors shall be located to keep suction lines as short as possible. Drivers for compressor may be electric motor, gas engine, gas-fired turbine or steam turbines as per P& ID. The gas compressors shall be located downwind side of furnace so that leaks are not blown towards furnace. In general compressors are kept under shed. When compressors are kept under shed, sides are fully open for the low shed or partially closed from top for high shed to avoid accumulation of heavier gases in the shed.

In case of a turbine driven compressor, if exhaust steam is condensed, turbine and compressor to be located at an elevated level and condenser to be located below turbine.

A major consideration in centrifugal compressor location is the lube and seal oil console. It must be accessible from road and must be lower than the compressor to allow gravity drain of oil to the consoles oil tank.

Intercoolers are placed near compressor and are kept within/outside shed, keeping the safe distance.

Knockout pots and after coolers where used may be kept outside the shed but near compressor house.

For compressors one Electrically Operated Crane to handle heaviest removable piece shall be provided for each compressor house. Maintenance bay for compressors shall be provided. Maintenance bay shall be accessible from road to facilitate unloading of load on to truck etc. For removal of bundles of exchangers located within building monorail arrangement shall be provided.

Compressor manufacturer may be consulted for better layout and additional requirement for maintenance. However licensor’s requirement, if any, shall also be taken into consideration.

In case the compressors are located at grade level; the finished floor level for compressor house shall be 300 mm above HPP. However if the compressors are located at elevated structure the finished floor can be same as HPP.
Main Lube Oil Pump for all Turbines driven Pumps & Compressors shall be motor driven and independent. There shall be 1+1 lube oil pumps and one shall be in line and one pump shall be standby. The stand by lube oil pump shall start automatically if lube oil pressure drops below the minimum required lube oil pressure in the system. Similarly there shall be one additional lube oil pump in addition to the two pumps which shall start in case of power failure. Provision of Coast down tank shall also be made.

Lube oil pumps driven by compressor or turbine shaft are not acceptable.

Lube oil pumps /seal oil pumps shall be mounted separately. No vertical lube oil pumps/seal oil pumps mounted on Lube oil tank are acceptable.

Lube oil tank and all lube oil related piping i.e. supply and return lube oil piping shall be of SS material only.

The inter stage coolers of compressors shall be separately provided so that they can be assessed easily for any maintenance job. The inter stage coolers of compressors mounted on the same frame or below the compressor in the same frame to make it compact structure is not acceptable.

Vertical reciprocating compressor for any service is not acceptable.

The Turbine – compressor system shall be provided with duplex type lube oil filters and lube oil coolers so that at a time one lube oil cooler and one lube oil filter will remain in line and other lube oil cooler with filter shall remain as stand by.

The Turbine – compressor system shall be provided with duplex type lube oil filters and lube oil coolers so that at a time one lube oil cooler and one lube oil filter will remain in line and other lube oil cooler with filter shall remain as stand by. Duplex type filters with smooth manual change over arrangement shall be provided. Filter material shall be corrosion resistant to water in the oil. Lube oil system shall be provided with lube oil centrifuge to remove the water in the lube oil.

5.2.3.11 Clearance and Accessibility

1. Crane Access & Tube bundle pulling

Equipment, structures shall be arranged to permit crane access to service air coolers, compressors and exchangers. All exchanger tube bundles shall be "jacked out" against shell. A clear space for tube bundle removal shall be provided. Dropout bay may be considered for exchangers at elevated structures. For high pressure exchangers, shell pulling on rails should be considered.

2. Access to Pumps

Clear access of 3.8M vertically and 4.5M horizontally shall be provided centrally under main pipe rack for small mobile equipment to service pumps, wherever these are put under pipe ways with prior specific approval. Pumps outside rack shall be approachable by small cranes etc. from under the pipe rack.

3. Access to lower items to grade (lowering Area)

Clear access shall be provided at grade on the access side for lowering external and internal fittings from tall elevated equipment by providing pipe davits.
4. Layout & Access Requirements for Platforms ladders and Stairs

For providing platform staircase following guidelines shall be followed.

- Two means of access (i.e. two stair case one ladder and one stair case) shall be provided at any elevated platform which serves three or more vessels & for B/L valves operating platform.
- Platforms, stairways shall be the minimum, consistent with access and safety requirements.
- Stairway for tanks to be provided on upstream of predominant wind direction.

i) Platform at elevated structure
   - Dual access (i.e. two stair case) shall be provided at large elevated structure if any part of platform has more than 22.65M (75 ft) of travel.
   - Air coolers shall have platforms with interconnected walk-ways provided to service valves, fan motors and instruments. Access requirements shall conform to paragraph (a) above.
   - When fired heaters are located adjacent to one another, they shall have inter-connecting platforms on the upper and lower section. Inter-connecting platforms between towers may be provided taking into consideration expansion of towers.

ii) Platforms with stair access shall be provided for:
   - Location at which normal monitoring (once a day or more) is required or where samples are taken.
   - Locations where vessels or equipment items need operator attention "such as compressors, heaters, boilers etc.

iii) Platforms with ladder access shall be provided for:
   - Points which require occasional operating access including valves, spectacle blind and motor operated valves, and heater stack sampling points.
   - Man ways above grade on equipment.

iv) Ladder location
   - Wherever practicable, ladder shall be so arranged that users face equipment or platform rather than facing open space.
   - Landings shall be staggered. No ladder shall be more than 8M in one flight.

Clearances

Minimum clearances shall be as indicated in Annexure - 5.

5.3 Unit Piping

5.3.1 Basis of Unit Piping

- Piping & Instrument Diagram
- Equipment layout
- Equipment Data sheet & Setting plan
- Line list
- Instrument Data sheet
- Structural & building drawings
- Topography of the plant
- Piping material specification
- Overall plot plan
The following objective shall be ascertained during piping layout.

- Proper access to all operating points including valves, and for all orifice tapping points and instruments in particular (refer Annexure-2).
- Proper access to interrelated operating points for specific purpose and for maintenance.

5.3.2 Pipe Ways/Rack piping

5.3.2.1 Racks shall be designed to give the piping shortest possible run and to provide clear head rooms over main walkways, secondary walkways and platforms.

5.3.2.2 Predominantly process lines are to be kept at lower tier and, utility & hot process lines on upper tier.

5.3.2.3 Generally the top tier is to be kept for Electrical (if not provided in underground trench as per electrical design basis) and Instrument cable trays. Cable tray shall be laid to take care of necessary clearances for the fire proofing of structure.

5.3.2.4 Generally the hot lines and cold lines shall be kept apart in different groups on a tier.

5.3.2.5 Generally the bigger size lines shall be kept nearer to the column.

5.3.2.6 Minimum spacing between adjacent lines shall be decided based on O.D of bigger size flange (minimum rating 300# to be considered), O.D of the smaller pipe, individual insulation thickness and additional 25 mm clearance, preferably.

Wherever even if flange is not appearing the minimum spacing shall be based on above basis only.

5.3.2.7 Actual line spacing, especially at 'L' bend and loop locations, shall take care of thermal expansion / thermal contraction / non expansion of adjacent line. Non expansion / thermal contraction may stop the free expansion of the adjacent line at 'L' bend location.

5.3.3 Column / Vessel Piping Control Valves

5.3.3.1 Piping from column shall drop or rise immediately upon leaving the nozzle and run parallel and as close as practicable to vessel. Re-boiler outlet piping shall be as short as possible with minimum bends.

5.3.3.2 Piping shall be grouped as far as possible for the ease of supports and shall run on the rack side of the column.
5.3.3.3 Manholes shall be kept on the road side of the column and approachable from the platform. Platform width shall be such that minimum 1.0 M space is available beyond manhole for movement.

5.3.3.4 Piping shall be supported from cleats welded on the vessel as far as possible.

5.3.3.5 Proper guides at intervals shall be provided for long vertical lines.

5.3.3.6 Access platforms/ladders shall be provided along the column for valves and instruments. Minimum width of platform shall be 750mm clear.

5.3.3.7 For ease of operation and maintenance, column and vessels which are grouped together, shall have their platforms at the same elevation interconnected by walkways wherever feasible. However each column \ vessel shall have an independent access also. Column vessel platforms should be designed in such a way so that all the nozzles should be approachable from platforms.

5.3.3.8 Unless specifically indicated in P&ID’s control valves shall preferably be kept at grade instead of platform.

5.3.3.9 Piping intended for vacuum services shall be routed as short as possible, with minimum bends and flanged joints.

5.3.3.10 Piping support cleats shall be designed for safety valves considering impact loading during popping off.

5.3.4 **Exchanger Piping**

5.3.4.1 Exchanger piping shall not run in the way of built in or mobile handling facilities.

5.3.4.2 Wrench clearance shall have to be provided at exchanger flanges.

5.3.4.3 Piping shall be arranged so that they do not hinder removal of shell end and channel cover and withdrawal of tube bundle.

5.3.5 **Heater / Furnace Piping**

5.3.5.1 Arrange piping to permit burner removal by providing break up flanges in the piping.

5.3.5.2 Burner valves shall be located close to peep holes for operation. Piping to burners shall be arranged in such a way to give equal and sufficient quantity of oil/gas to all burners.

5.3.5.3 Only flexible metallic SS hoses shall be used for burner piping if required.

5.3.5.4 Block valves for emergency snuffing steam valves shall be located minimum 15M away from the heater, preferably on the upwind side of the heater.

5.3.5.5 Piping from various passes of heater outlet nozzles should preferably be symmetrical. Transfer line from heater to column shall be as short as possible, without pockets, free draining and with minimum bends.

5.3.5.6 No piping shall be routed in the tube withdrawal area. If unavoidable, break up flanges shall be provided in the piping for removal.

5.3.5.7 All furnaces, if they are located in the same area they should be interconnected with platforms at different locations.

5.3.6 **Pump Piping**

5.3.6.1 Pump drives shall have clear access.

5.3.6.2 Pump suction piping shall be as short as possible and shall be arranged with particular care to avoid vapor pockets.
5.3.6.3 Reducers immediately connected to the pump suction shall be eccentric type flat side up to avoid the accumulation of gas pocket. For end suction pumps, elbows shall not be directly connected to the suction flange. A straight piece minimum 3 times the line size shall have to be provided at the suction nozzle.

5.3.6.4 Pump discharge check valve if installed in vertical lines shall be fitted with a drain connection as close as possible downstream of the valve. When a suction vessel operates under vacuum, the vent connection of the pump has to be permanently connected to vapor space of the suction vessel to allow possible filling of the pump with liquid before it is started.

5.3.6.5 Unless otherwise specified T-type strainers with drain shall be used on pump suction piping for sizes 2" and above.

5.3.6.6 Y-type strainers with drain to be used for all sizes in steam services and for pump suction lines 1½ and below.

5.3.6.7 All small bore piping connected to pump (drain to OWS & CBD, seat and gland leak drain) shall have provision for break up flanges for removal of pumps.

5.3.6.8 Piping shall be so arranged that forces and moments imposed on the pump nozzle do not exceed the allowable values as per API 610 or manufacturer’s recommended.

5.3.6.9 Pump discharge should preferably be routed away from the pump rather than towards the motor side.

5.3.6.10 Pump cooling water connection shall be taken from the top of circulating cooling water header.

5.3.6.11 A minimum straight length of suction pipe is to be provided as per manufacturer’s recommendation.

5.3.7 Compressor Piping

5.3.7.1 Suction lines shall be as short as possible.

5.3.7.2 Suction piping shall have adequate flanged joints for ease of erection and maintenance.

5.3.7.3 Lube oil cooler space shall be provided such as to facilitate tube bundle removal.

5.3.7.4 All operating valves on main suction and discharge piping shall be lined on one side as far as possible.

5.3.7.5 A minimum straight length of suction pipe is to be provided as per manufacturer’s recommendation.

5.3.7.6 Piping shall be designed so that forces and moments imposed on the compressor do not exceed the manufacturer's recommendation.

5.3.7.7 Compressor suction lines between the knockout drum and the compressor shall be as short as practicable."

5.3.7.8 Where the line between knockout drum and the compressor cannot be routed without pocket, low point in compressor line shall be provided with drains to remove any possible accumulation of liquid. In no case accumulation at low point should be allowed to go towards the compressor.

5.3.7.9 Low points in the discharge line from an air compressor shall be avoided because it is possible for lube oil to be trapped and subsequently ignited. If low points are unavoidable, they shall be provided with drains. In case of reciprocating compressor, piping shall be suitably supported to avoid vibrations due to pulsating flow. Unless specific requirements of no pockets are there from the licensor, all
the piping shall run at 500 mm above grade level so that proper supports can be provided and also to minimize vibrations.

Analog study shall be carried out for complete compressor piping including suction I discharge piping as per P&ID’s and the analog study recommendations if any, shall be implemented.

5.3.7.10 Reciprocating compressor piping should not be supported from compressor shed I platform structure.

5.3.8 Relief System/blow down System Piping (CBD, OWS, FLARE)

5.3.8.1 Relief of liquids and easily condensable hydrocarbons are usually discharged to a closed system.

5.3.8.2 Wherever the inlet line size is higher than the safety valve inlet size, reducer shall be installed adjacent to inlet of safety valve.

5.3.8.3 Relief valve discharging steam, air or other non-flammable vapor or gas directly to atmosphere shall be equipped with drain and shall be suitably piped to prevent accumulation of liquid at valve outlet. Liquid phase blow down system piping connected to a closed system shall be self draining to the blow down drum. Closed blow down header shall be sloped towards the CBD drum to assure free drainage.

5.3.8.4 Liquid-vapor phase relief valves shall discharge into the flare header at an angle 45 degrees in the direction of header flow, to minimize the effect of kinetic energy and to avoid accumulation of liquid.

5.3.8.5 Pockets in the flare header and blow down system shall be prohibited.

5.3.8.6 Relief valve discharge piping shall be taken to safe location as per following. 3M above top platform of column or structure, within 6M radius for steam and 8M for Hydro carbon / toxic discharge. 25M horizontally away from furnace.

5.3.8.7 Inlet and outlet piping of pressure relief valve shall be adequately supported to take care of the thrust induced by the relief valve during popping. Reaction forces due to safety valve popping shall be ascertained in the connected piping. The effect of these forces on the piping supports and the anchors of the piping system shall be calculated to ascertain that the allowable limits at these locations are not exceeded. The supporting structure also shall be adequately designed so that when subjected to these reaction forces the supporting elements connected to piping as well as the basic .supporting structure i.e. platform members etc. are capable of withstanding them. System stresses in the inlet and outlet piping portions at safety valves also shall be kept within the allowable limits, inclusive of the distribution branching points in the inlet portion. These reactive forces shall not lead to any leakage at the flanged joints present in the system. To ascertain these necessary calculations for checking leakage at the flanged joints shall be performed.

5.3.9 Steam Piping - Indian Boiler Regulations (IBR)

Generally steam lines with conditions listed below fall in the scope of IBR.

- Lines having design pressure (maximum working pressure) Above 3.5 kg/cm² (g)
- Line sizes above 10” inside diameter having design pressure 1.0 Kg/cm² (g) & above.
- Lines with pressure less than 1.0 Kg/cm² (g) are excluded.
• Users of steam like steam tracing lines, jacket of the steam jacketed lines, 
steam heating coil within the equipment are excluded from IBR scope.

• Boiler feed water lines to steam generator, condensate lines to steam 
generator and flash drum as marked in P&I D shall be under purview of IBR.

IBR requirements (in brief)

a) All materials used on lines falling under IBR must be accompanied with IBR 
Inspection Certificate in original. Alternatively, photocopy of the original 
certificate duly countersigned and attested by local IBR inspector is 
acceptable. Whereas for indigenous supply, only IBR is the inspection 
authority.

b) Drawings like General Arrangement Drawings (GAD) and system isometrics / 
line wise isometrics of lines falling under IBR must also be approved by IBR 
authority of State in which the system is being installed.

c) All welders used on fabrication of IBR system must possess IBR welding 
qualification certificate.

d) IBR system must be designed to comply IBR regulations as well as ASME 
B31.1. All design calculations towards the same must be approved by IBR 
authority.

e) IBR approval is obtained with requisite fees payable to Indian Boiler Board of 
the State concerned.

f) Steam generators (boilers/heat exchangers) shall require exclusive IBR 
approval along with its integral piping up to the final isolation valve.

g) The discretion of IBR authority of state is final and binding for the above 
cases.

5.3.10 Steam Header & Supply Lines / steam and Condensate Systems

5.3.10.1 Steam piping shall be designed to have complete condensate removal. Drip legs 
shall be provided with steam traps at low points in the system.

5.3.10.2 All steam branch connections shall be taken from the top of the header.

5.3.10.3 Return exhaust steam / condensate lines shall connect to the top of the exhaust 
steam Condensate header.

5.3.10.4 Where block valves have been installed in the main steam header such that 
condensate can collect either side of the valve when closed, a safe means of 
draining the condensate prior to opening the valve shall be provided.

• Steam header shall be located generally on the upper tier and at one end of 
the rack adjacent to columns.

• Branch lines from horizontal steam header, except condensate collection 
points, shall be connected to the top of the pipe header.

• Isolation valves (if provided) on the branch line shall preferably be provided on 
the horizontal run and outside the pipe rack.

• All branch lines shall be drainable.

• Drip legs & steam traps shall be provided at all low points and dead ends of 
steam header. Drip legs at low points shall be closer to downstream riser and 
shall be provided to suit bidirectional flows, if applicable.

• All turbines on automatic control for startup shall be provided with a steam trap 
in the steam inlet line.

• All traps shall be provided with strainers if integral strainers are not provided.

• Steam traps discharging to atmosphere shall be connected to storm water 

drain/storm sewer, in case of open system. In case of condensate recovery, 
traps shall discharge into condensate header.
• Expansion loops are to be provided to take care of the expansions within units.
• Wherever condensate is to be drained, proper condensate draining facility shall be provided.

5.3.11 Steam Tracing

5.3.11.1 Tracers for the individual lines shall be supplied from manifolds when there are two or more connections. Steam supply headers shall be located on continuous platform along the rack. No steam supply station shall be located at grade.

5.3.11.2 Standard module for steam distribution and condensate collection manifolds with integral glandless piston valve and thermostatic steam trap shall be used. Number of tracers shall be 4/8/12 and tracer size 0.5” NB to .75” NB depending upon the detail engineering requirement. 20% or minimum 2 no. tracer connections shall be kept spare for future use for both steam supply and condensate collection manifolds.

5.3.11.3 All manifolds shall be installed in vertical position and manifold size shall be 3” NB for conventional and 1 ½” NB for compact type.

5.3.11.4 For steam tracing balanced pressure thermostatic steam trap with 40 mesh SS strainer to be used.

5.3.11.5 Manifolds shall be accessible from grade or from a platform.

5.3.11.6 Pockets in steam tracers shall be avoided as far as possible.

5.3.11.7 Tracers shall be limited to the following run length upstream of traps:

<table>
<thead>
<tr>
<th>Size of tracer</th>
<th>Length of tracer pipe (Meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam operating pressure</td>
<td></td>
</tr>
<tr>
<td>20 psig</td>
<td>50 psig</td>
</tr>
<tr>
<td>30</td>
<td>45</td>
</tr>
</tbody>
</table>

Tracers shall generally be of 0.5”. Tracers shall be of CS steel seamless pipe and valves on the steam tracing circuit including steam station block valve shall be glandless piston type construction. Heat transfer cement shall be applied in between main pipe and tracer pipe to improve heat transfer.

5.3.11.8 Size of the lead line to manifold shall be as follows:

<table>
<thead>
<tr>
<th>Number of connections</th>
<th>Size of Lead Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3/4”</td>
</tr>
<tr>
<td>3</td>
<td>1”</td>
</tr>
<tr>
<td>4-6</td>
<td>1 1/2”</td>
</tr>
<tr>
<td>7 -12</td>
<td>2” NB</td>
</tr>
</tbody>
</table>

The lead line to manifold, manifold up to the block valves of individual tracer shall be carbon steel of IBR quality and conforms to IBR act.

Tracer lines shall be provided with break up flanges for main line flange joints and valves.

All tracers shall have individual steam traps before condensate manifolds.

Condensate manifold including the last valve on individual tracer shall be of carbon steel.

All steam traps discharging to a closed system shall have a block valve upstream and downstream of the trap. A bypass globe valve shall be installed around the trap. Check valve shall be installed on the downstream of the steam trap near the condensate header in case discharging to a closed system.
Number of tracers required on a line shall be as follows:

<table>
<thead>
<tr>
<th>Size of Line</th>
<th>Number of Tracers</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 4&quot; NB</td>
<td>1</td>
</tr>
<tr>
<td>6&quot; NB to 16&quot; NB</td>
<td>2</td>
</tr>
<tr>
<td>18&quot; NB to 24&quot; NB</td>
<td>3</td>
</tr>
<tr>
<td>26&quot; NB &amp; above</td>
<td>To Calculate</td>
</tr>
</tbody>
</table>

Steam Jacketing System

A steam jacketed pipe consists of a product line which passes through the centre of a larger diameter steam line.

The nominal size of the inner pipe (CORE) and outer pipe (JACKET) in inches shall be as per table below unless otherwise mentioned in project piping material specification (PMS) or P&ID.

<table>
<thead>
<tr>
<th>Core pipe</th>
<th>Jacket pipe</th>
<th>Steam feeder to jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot; NB</td>
<td>1-1/2&quot; NB</td>
<td>0.5&quot;</td>
</tr>
<tr>
<td>1&quot; NB</td>
<td>2&quot; NB</td>
<td>0.5&quot;</td>
</tr>
<tr>
<td>1-1/2&quot; NB</td>
<td>3&quot; NB</td>
<td>0.5&quot;</td>
</tr>
<tr>
<td>2&quot; NB</td>
<td>3&quot; NB</td>
<td>0.5&quot;</td>
</tr>
<tr>
<td>4&quot; NB</td>
<td>6&quot; NB</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td>6&quot; NB</td>
<td>8&quot; NB</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td>8&quot; NB</td>
<td>10&quot; NB</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td>10&quot; NB</td>
<td>12&quot; NB</td>
<td>0.75&quot;</td>
</tr>
</tbody>
</table>

For jacketed lines using high pressure steam, actual calculations for core, jacket and feeder pipe shall be performed before finalization of sizing.

Distance between steam inlet and condensate outlet shall be similar to steam tracing system. Baffle plates, flanged joints or end caps shall be used to discontinue one feed length from the next.

Flanged jump over shall be used in case of a flanged joint. In case of discontinuous jacketing simple jump-overs shall be employed. The length of jacket shall be 4 to 5 meters or as mentioned in job specification.

Intermediate partial baffles shall be provided if a separate branch portion is to be heated from the main line stream.

Steam inlet to jacket shall generally be provided from top of the pipe in case of horizontal lines. The jump over and condensate outlets shall be from the bottom.

In case of vertical lines steam inlet shall be done at the topmost points and condensate outlet shall be done from the lowest possible points. Two consecutive Slipovers shall be 180 deg. apart.

Each feed length shall be provided with individual trap before connecting to condensate recovery headers.

Balanced pressure I bi-metallic type thermostatic steam traps with 40 mesh strainer shall be used in jacketing.

To keep proper concentricity between core and jacket pipe internal guides (rods or flat bars) shall be provided at intervals depending on the size of the pipe.

Wherever anchors are provided on jacket lines proper interconnection of jacket pipe and core pipe shall have to be provided with proper jump over for steam.
5.3.12 Utility Stations

Requisite number of utility stations shall be provided throughout the unit to cater for the utility requirement. Utility stations shall have four connections [one for LP steam (SL), one for Plant Air (AP) and one for Service Water (WS)) each of 1.0” NB unless otherwise specified in P&ID.

Air and water lines shall have quick type hose connection and steam line shall have flanged type hose connection. All connections shall be directed downward. All connections shall have globe valve for isolation purpose. An inter connection with valve shall be provided between steam and service water lines shall be provided. Inert gas hose, when required, shall have built in non return valve in quick connection coupling of piping end.

Number of utility stations shall be such that all equipments shall be approachable from at least one utility station. The approach of utility station shall be considered 15M all around the station location.

The Utility stations shall generally be located adjacent to pipe-rack column. The utility stations shall also be provided on elevated structures like - technological structure, operating platforms of vertical equipments etc. Operating platforms having manholes must have a utility station. Utility station locations shall be limited to a height of 35 M from H.P.P.

5.3.13 Fire Fighting

All fire fighting facilities shall be as per statutory norms. Fire fighting points are to be provided for fighting fire at highest elevation in case of tall columns.

The following points to be considered in designing of Fire Fighting system.

i) Water sprayer for all compressors shall be provided with control valves

ii) Complete firefighting system fulfilling all the applicable requirements (as required by TAC and NFPA rules) such as hydrants, monitors, sprinklers, clean agent system, fire detection and alarm system, first aid fire fighting equipments, communication with central fire station etc. shall be designed and provided for Steam Generation plant by LSTK contractor.

iii) LSTK contractor shall finalize these firewater mains w.r.t. size and location and hook up with the Offsite fire water mains along with an isolation valve and all the requirements as mentioned above. Location of offsite fire water mains shall be mentioned in the drawing “Conceptual layout of Fire Fighting system” for Integrated Coal Based Fertilizer Complex at Talcher and shall be issued by Owner/OSBL Contractor during detail engineering.

iv) Fire water ring header shall be underground laid in the RCC trench with corrosive protective Tape coated, filled with sand and covered with RCC slab.

v) Valves on fire water mains shall be of Gate type only. Valves on fire water lines shall be located in RCC valve chamber provided with top cover to facilitate easy operation/ maintenance of valves. The top of chamber shall be 80 mm above ground level.

5.4 Offsite & Yard Piping

In general, offsite piping, electrical cable and instrumentation cable shall also be laid either on pipe rack or pipe sleepers.
Wherever piping is laid on pipe sleepers, it shall have hard surfacing below it keeping a gap of 300mm from the bottom of the pipes. Hard surfacing should be completed before start of pipe laying. Width of hard surfacing shall be about 1.0 meter more than the piping corridor. This extra hard surfacing shall be for movement of operating personnel along the piping corridor.

Pipes at road crossing shall be under culverts in general. Overhead pipe bridges may be used for areas where pipe racks are provided. Where culverts are not provided, pipe sleeves shall be used for underground road crossing. Culverts / overhead pipe bridges shall be adequately designed to take care of future requirements. Minimum 20% extra width shall be provided in all such structures.

Clearances between lines shall be minimum "C" as given below:

\[ C = \frac{(D_o + D_f)}{2} + 25 \text{ mm} + \text{Insulation thickness (es)} \]

Do - outside diameter of smaller pipe (mm)
Df - outside diameter of flange of bigger pipe (mm)

However this 'C' spacing between the offsite piping on the rack/sleeper can be suitably increased so that the lines should not touch each other after insulation / lateral thermal expansion.

Adequate clearance shall be provided for every long & high temperature lines to avoid clashing at the bends. See 5.2.2.6 also for line spacing at 'L' bends and loops.

Expansion loops for all lines shall generally be kept at the same location.

Vents shall be provided on all high points & drains shall be provided at all low points. Drain valves at sleeper piping shall be kept outside the sleeper way if the same is not accessible and valves shall be put in horizontal only.

Places where piping is extended to make drain valves accessible - 2 nos. of stiffeners, irrespective of pipe rating, shall be provided. Spacing of guides on each line on a pipe bay shall not exceed the value given in ANNEXURE-3

5.5 Flare Piping

Flare header shall be sloped towards flare knock-out drum. Only horizontal loop shall be provided as per requirement to accommodate thermal expansion. The desired slope shall be ensured throughout including flat loop. Flare header shall be supported on shoe of height ranging from 100mm to 300mm.

Proper thermal analysis temperature shall be established including the possibility of temperature gradient along the line before providing expansion loops. Efforts shall be made to minimize the number of loops. Flare line between knock out drum and water seal drum shall be designed for pressure fluctuations and adequately supported to avoid vibrations.

5.6 UNDERGROUND PIPING

5.6.1 Buried Pipes

The following points to be considered in designing of buried pipes

i) All underground metallic piping shall be coated and wrapped and provided with cathodic protection system. If sacrificial metal is used, permanent testing arrangement shall be provided.
ii) All cooling water distribution headers 18” NB and higher shall be laid underground.

iii) All Sewage lines (oily and chemical) from catch basin to mains and manholes shall be laid underground.

iv) Underground pipe crossing roads, access ways, rails shall have casing pipe (R.C.C or C.S)

v) Valve chamber wherever required shall be made of brick or concrete with waterproofing. Valve chamber should be spacious to attend valves during operation/ Maintenance.

vi) All U.G. headers shall clear equipment foundations as far as possible. Under special cases, the C.W. header may be laid over the footing of foundations.

vii) Provide break flange at +500 MM from floor level connection with cathodic protection to isolate underground pipe from above ground piping.

viii) Pipes shall be laid below electrical cables if any.

ix) Depth for Underground Buried piping shall have at least 1.0 meter earth cushion in open ground and 1.5 meters earth cushion under the roads and areas where crane movement is involved.

5.6.2 Piping in Trenches

The following points to be considered in designing of trench pipes

i) Piping located below grade, requiring inspection, servicing or provided with protective heating.

ii) Fire water lines/Process lines.

iii) Drain lines requiring gravity flow trenches.

iv) Sump for valves and trenches shall be provided.

v) Suitable draining scheme for trenches shall be provided. Underground cooling water line shall be considered with cathodic protection.

5.7 Air Systems

5.7.1 Branch connections shall be taken from the top of the header.

5.7.2 Low points shall be fitted with drains.

5.8 In-Line Instruments

5.8.1 Liquid level controllers and level glasses shall be located so as to be accessible from grade, platform or permanent ladder. The level glass shall be readable from grade wherever possible.

5.8.2 Relief valves shall be accessible. Relief valves with a centre line elevation over 4.5m above grade (except in pipe racks) shall be accessible from a platform or permanent ladder.

5.8.3 Relief valves that discharge to a closed system shall be installed higher than the collection header, with no pockets in the discharge line.

5.8.4 Relief valves that discharge to atmosphere shall have tail-pipes extended to a minimum of 3.0 m above the nearest operating platform that is within a radius of 8m.
5.8.5 Provide steam traps at pocketed low points and at dead ends of steam headers. Provide steam traps on excessively long runs of steam piping to ensure dry quality steam at destination. Steam traps located more than 4.5m above grade, except in pipe racks, and shall be accessible from a platform.

5.8.6 Control valves shall be accessible from grade or platforms. In general, the instruments or indicators showing the process variables shall be visible from the control valve.

5.8.7 Orifice runs shall be located in the horizontal. Orifice flanges with a centre line elevation over 4.5m above grade, except in pipe racks, shall be accessible from a platform or permanent ladder.

5.8.8 Orifice taps shall be located as follows:
   i) Air, Gas and steam
      Top vertical centreline (preferred)
      45 degrees above horizontal centreline (alternate)
   ii) Liquid
      Horizontal centreline (preferred)
      45 degrees below horizontal centreline (alternate)
   iii) Tap orientation shall be shown on piping isometrics.

5.9 Sample Connections
5.9.1 Sample connections shall be accessible from grade or platforms. In general, where liquid samples are taken in a bottle, locate the sample outlet above a drain funnel to permit free running of the liquid before sampling.

5.10 Vents and Drains
5.10.1 Valve bleeds shall be provided at control valve stations, level switches, level controllers, and gauge glasses.

5.10.2 Process vents and drains shall be indicated on the P&ID’s.

5.10.3 Low-point hydrostatic drains and high-point hydrostatic vents shall be added as required; locations to be determined during the Design review.

5.11 Line Strainers
5.11.1 Provide temporary conical type strainers in 2” NB and above butt weld pump suction lines for use during start-up. Arrange piping to facilitate removal of particles.

5.11.2 Provide permanent Y-type strainers on 2” NB and smaller screwed or socket-weld pump suction piping.

5.11.3 Provide temporary basket type strainers located at the suction pulsation device inlet for start-up of reciprocating compressors. Arrange piping to facilitate removal of the filter.

5.11.4 Provide temporary basket type strainers and locate them as close as possible to the compressor inlet flange for start-up of centrifugal compressors. Arrange piping to facilitate removal of the filter.
5.12 Spectacle Blinds
5.12.1 Spectacle blinds shall be provided to isolate equipment. In hazardous service flanged drop-out spools shall be provided for safety purposes. Both shall be shown on the P&ID’s.
5.12.2 Spectacle blinds shall be accessible from grade or platforms. Blinds located in a pipe-rack are considered to be accessible. Blinds that weigh over 40kg shall be accessible by mobile equipment. Where this is not possible davits or hitching points shall be provided.

5.13 Flexibility Analysis and Supporting

5.13.1 Pipe Supporting Criteria & General Guidelines.

Piping system shall be properly supported taking into account the following points:
1. Load of bare pipe + fluid + insulation (if any).
2. Load of bare pipe + water fill.
3. Load of valves and online equipment and instrument.
4. Thermal loads during operation.
5. Steam-out condition, if applicable.
6. Wind loads for piping at higher elevation, e.g. transfer lines, column over head lines, flare headers, etc.
7. Forced vibration due to pulsating flow.
8. Vibration due to two phase flow.
9. Loads due to internal pressure.
10. Any external loads/concentrated loads and cold load of springs.

Pipe supporting shall preferably follow the minimum basic span as given in Annexure-1 except for flare line in off site on trestles in which case the maximum basic span shall be restricted to 18.0 meters, irrespective of line size.

For sizes not covered in Annexure-1, basic span shall be established based on project requirement. For piping on rack or sleeper, as a minimum, providing resting support on every grid of pipe rack / sleeper is mandatory. Depending on the pipe size, as a rule, guides shall be provided on straight run of pipes at intervals as specified in Annexure-3 unless specifically becomes non-viable due to flexibility problems.

Additional supports, guides, anchors, special supports like spring supports and sway braces shall be provided after detailed analysis of piping system to restrict the forces experienced on nozzles of critical items like pumps, compressors, turbines, exchangers, air fin coolers etc.

For lines which do not need any support otherwise but become unsupported by opening of flange, etc, during maintenance and thereby may transfer the total load on a small branch off, a permanent support shall be suitably provided which may be a spring support also. Bare pipes of size 14” and above on elevated structures shall be supported with pad or shoe. While bare pipes of size 6" and above, on sleepers, corrosion pads shall be provided.

Pads shall be provided for insulated pipes before welding the shoes for sizes 8”& above.

Adequate stiffening shall be provided for the following:
a) Lines in above 600#,  
b) Lines having two phase flow,  
c) Lines having Pulsating flow such as discharge of reciprocating compressors & reciprocating pumps,

For pulsating flow lines detailed thermal and vibration analysis by analog study shall be done to decide location of anchor supports and guides etc. Pulsating flow lines shall be as identified by licensor/owner.

Wherever two phase flow in piping is expected, piping design shall be checked by dynamic analysis to prevent vibrations.

Pipe support design shall be such that deflection in piping systems due to sustained loads shall not exceed 15mm, in any case, between two adjacent supports.

As far as possible long trunnion types of supports (more than 0.5 metre) are to be avoided. In case long trunnion support is unavoidable in straight length of pipe, trunnion height to be restricted to 0.5m and balance height to be made up by providing extended structure.

In the heaters where steam air decoking provision is there, the main lines and decoking lines should be supported in a way so that either of the lines should not be in the hanging position while connected to other one. Same philosophy shall be adopted for similar type of switch over arrangement.

Piping passing through the technology structure or passing near the concrete column etc. should have adequate annular space to avoid restriction of line movement during thermal expansion. The gap should take care of the thermal expansion along with insulation thickness.

All pipes supports shall be so designed that there is no undue tension on equipment flanges. Flange joints should not move away from each other in case of unbolting of the joint.

5.13.2 Flexibility Analysis Criteria & General Guidelines

5.13.2.1 Formal computer analysis shall be performed on piping systems as per design philosophy for stress analysis (Refer Annexure-7)

5.13.2.2 The directions of forces and moments shall be in accordance with Welding Research Council Bulletin 107 (WRC 107), with the exception that the radial force (P) shall be away from the vessel. All forces and moments shall be assumed to act simultaneously and apply at the nozzle/vessel interface.

5.13.2.3 Air coolers to API 661 shall be specified with Fx forces and Mz moments increased to 1.2 times the value shown in Figure 8 of API 661 for nozzle sizes 6"NPS and larger to simplify piping flexibility analysis and facilitate piping layout.

5.13.2.4 Piping stress analysis and equipment nozzle loading analysis shall be in accordance with ASME B31.1 and the relevant API, ANSI/ISO and NEMA Codes.

5.13.2.5 The allowable nozzle loads on centrifugal pumps shall meet the load criteria of API 610. Heavy duty base plate shall be specified where the pump design temperature is in excess of 150°C.

5.13.2.6 For piping design purposes, differential settlement between items of major equipment on separate foundations shall be taken as 10mm.
5.13.2.7 Cold springing in piping shall not be permitted without written permission from the Owner/PMC. Cold springing of piping directly connected to rotating equipment is not permitted under any circumstances.

Piping shall be analyzed for expansion, contraction, differential settlement, relief, valve reaction and effects mentioned at CI. 5.12.1.

The design of piping systems shall take into account the different conditions expected during operation, start-up, shut-down, cold branch in case of standby pump, tracing, etc. Hydrocarbon lines shall be designed for steam-out conditions, if specified in line schedule. The use of expansion joints shall be considered only when space or pressure drop limitation does not permit pipe bends. Expansion joint of axial type shall be avoided.

Forces and moments due to weight, thermal loads and other imposed loads on the equipment nozzle must not exceed the allowed loads for the equipment.

Minimum analysis temperature shall be the design temperature of the line as per line list.

5.13.3 Method of Analysis

Formal computer analysis shall be performed on piping systems as per design philosophy for stress analysis (Refer Annexure-7)

The package used shall be latest version of CEASER II. Only one of these packages shall be used for the project & not a combination of the above packages.

All lines shall be analyzed at design I analysis temperature. In the absence of analysis temperature lines shall be analyzed at design temperature.

However in case of wide difference in design and operating temperature, temperature for analysis shall be established in process documents.

All non-critical lines may be analyzed using other methods.

Special analysis methods shall be followed for lines involving pulsating flow such as those connected to reciprocating pumps & compressors which require acoustical plus analog study by approved agencies and shall require entire system analysis along with piping equipments.

Seismic analysis shall be done for line sizes 12” and above.

5.14 Personnel Protection

5.14.1 Eyewash and emergency safety showers shall be provided in areas where operating personnel are subject to hazardous sprays, emissions or spills.

5.14.2 Personnel protection shall be provided on un-insulated lines and equipment operating above 70°C when they constitute a hazard to the operators during normal operation of the facility.

5.14.3 Leakage indicating tape and spray impingement shrouds shall be provided at flanged joints in hazardous service.

5.15 Mechanical Handling

5.15.1 Handling facilities such as davits and monorails shall be provided on vessels over 10m in height where the weight of removable internal and/or external equipment is greater than 35 Kg.
6.0 Materials

Basic material selection of particular line depending on its service, temperature and corrosivity shall be spelt out in process package. Material specification shall follow the requirements as specified in PMS as per Licensor's requirement. PMS / VMS shall be supplied by bidder and will be approved by owner / PMC. PMS shall generally follow the requirements given in this section.

6.1 Piping Materials

6.1.1 All materials for piping components shall conform to the relevant code and/or specification.
6.1.2 All materials shall be new.
6.1.3 All plate, sections, pipe, fittings, flanges, valves and special items shall have Material Test Certificates.
6.1.4 All alloy materials shall have Material Certificates verifying the alloy content.
6.1.5 All bolting and gasket material shall have Letters of Compliance as a minimum.
6.1.6 All alloy bolting and gasketing shall have material Letters of Conformance verifying the alloy content.
6.1.7 All interconnecting piping and weld connections shall be designed in accordance with ANSI code for pressure piping B 31.1.
6.1.8 Only piping materials listed in ASME B31.1 shall be used for various critical services and Normal Service piping. For utility piping, where scaling and impurities are to be avoided (such as instrument air, potable water and deluge water) hot dipped galvanized and threaded fittings may be used in sizes up to and including 4" NB. Galvanized piping shall not be used in environments containing acids or other corrosive commodities. In corrosive environments stainless steel piping material shall be used for such utility systems.
6.1.9 For hazardous services no socket welded or threaded construction or connections shall be used for process equipment piping systems. Construction shall be by butt-welding with a minimum 20% radiography. Flanged connections shall be minimized.
6.1.10 All insulation and gaskets shall be asbestos free.
6.1.11 Insulating flange sets shall be provided between dissimilar materials as required.
6.1.12 Aluminium or copper alloys shall not be used for any component in the piping systems.
6.1.13 The use of 1.25Cr-0.5Mo alloy shall be a minimum requirement for piping systems having a design temperature 425°C and above.
6.1.14 Nelson Curves in accordance with API 941 shall be applicable to piping system materials in hydrogen service.
6.1.15 The minimum corrosion allowance for any material, other than stainless steel, shall not be less than 1.5mm. For stainless steel it is zero.
6.1.16 All instrument air pipe line shall be of SS304.
6.2 PIPE

6.2.1 Wall Thickness

6.2.1.1 Calculation of pipe thickness and branch reinforcement shall be based on requirements of ASME B31.1. Proper corrosion allowance and mill tolerance shall be considered to achieve the selected thickness.

6.2.1.2 For carbon steel and low alloy steel pipes (except for steam tracing piping) minimum pipe thickness shall be:
- S80 up to 0.75" NB,
- XS for 1" to 2" NB,
- STD for above 2" NB

For stainless pipes minimum pipe thickness shall be 40S up to 2", 10S for above 2" NB.

6.2.1.3 The philosophy of minimum thickness/schedule is applicable for both seamless and welded pipes.

6.2.1.4 The above mentioned minimum thickness/schedule criteria is not applicable to Firewater service and specification where IS pipes or welded API 5L pipes respectively etc., are being used.

6.2.1.5 All welded pipes shall have uniform negative wall thickness tolerance of 12.5% for wall thickness calculations purpose.

6.2.1.6 For thicknesses exceeding minimum thickness/schedule criteria, Schedule XS shall be selected for CS & AS classes (for 2" & above). Intermediate schedules between STD & XS shall be ignored. Similarly for SS classes (2" & above) S10, S20, S30 & 40S may be selected beyond minimum thickness/schedule criteria.

6.2.1.7 If, the thicknesses exceed XS in CS & AS classes and 40s in SS classes, only then, the thickness shall be calculated based on actual service conditions subject to a minimum of 80% class rating. Maximum 10% of corrosion allowance may be reduced in special cases, to optimize the pipe schedules.

In general, the pressure-temperature combination to calculate wall thickness shall be as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Class</th>
<th>Size</th>
<th>Design Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.S. (A 106 GR., B, API-5L GR.B, A672 GR.B60/C60 :CL 12) LTCS (A333 GR.6), Low Alloys (1.25% Cr- 0.5% Mo. 2.25% Cr-1.0% Mo. 5%Cr-0.5% Mo. 9%Cr- 1.0% Mo)</td>
<td>150</td>
<td>Up to 24&quot;</td>
<td>Class condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 24&quot;</td>
<td>Line condition #</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>Up to 14&quot;</td>
<td>Class condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 14&quot;</td>
<td>Line condition #</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>Up to 8&quot;</td>
<td>Class condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 8&quot;</td>
<td>Line condition #</td>
</tr>
<tr>
<td></td>
<td>900</td>
<td>Up to 8&quot;</td>
<td>Class condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 8&quot;</td>
<td>Line condition</td>
</tr>
<tr>
<td></td>
<td>1500 &amp; 2500</td>
<td>Up to 4&quot;</td>
<td>Class condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 4&quot;</td>
<td>Line condition</td>
</tr>
<tr>
<td>SS (A312 TP304, 304L.316L,321,347) OR (A358 TP304,304L,316, 316L, 321,347)</td>
<td>150</td>
<td>Up to 24&quot;</td>
<td>Class condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 24&quot;</td>
<td>Line condition ($)</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>Up to 14&quot;</td>
<td>Class condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 14&quot;</td>
<td>Line condition ($)</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>Up to 6&quot;</td>
<td>Class condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 6&quot;</td>
<td>Line condition ($)</td>
</tr>
</tbody>
</table>
### Design Philosophy – Piping

<table>
<thead>
<tr>
<th>Material</th>
<th>Class</th>
<th>Size</th>
<th>Design Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>900,1500</td>
<td>Up to 4”</td>
<td>Class condition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Above 4”</td>
<td>Line condition</td>
<td></td>
</tr>
<tr>
<td>2500</td>
<td>Up to 2”</td>
<td>Class condition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Above 2”</td>
<td>Line condition</td>
<td></td>
</tr>
<tr>
<td>Higher Alloys</td>
<td>150</td>
<td>Up to 6”</td>
<td>Class condition</td>
</tr>
<tr>
<td></td>
<td>Above 6”</td>
<td>Line condition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>300-2500</td>
<td>All sizes</td>
<td>Line condition</td>
</tr>
</tbody>
</table>

# only if the thickness/schedule as per class condition exceeds XS

$ Only if the thickness/schedule as per class condition exceeds 40S

Up to sizes 48", D/t ratio shall be restricted to 100(max.) Where D is nominal dia. And t is nominal thickness. However for utility services D/t ratio may be taken as max.150 where t is minimum calculated thickness excluding Corrosion and Manufacturing allowance.

#### 6.2.2 Pipe Size


#### 6.2.3 Pipe Type

<table>
<thead>
<tr>
<th>Material</th>
<th>Size</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS, L TCS, AS (except for cooling</td>
<td>Up to 14&quot;</td>
<td>Seamless</td>
</tr>
<tr>
<td>water, fire water services other</td>
<td>16&quot; and above</td>
<td>E.F.S.W</td>
</tr>
<tr>
<td>utilities &amp; LP hydrocarbon in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>offsite)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS Process lines</td>
<td>Up to 6&quot;</td>
<td>Seamless</td>
</tr>
<tr>
<td></td>
<td>8&quot; and above</td>
<td>E.F.S.W</td>
</tr>
<tr>
<td>SS Non process lines</td>
<td>Up to 1.50&quot;</td>
<td>Seamless</td>
</tr>
<tr>
<td></td>
<td>2&quot; &amp; Above</td>
<td>Welded</td>
</tr>
<tr>
<td>CS (Cooling water, fire water</td>
<td>ALL Sizes</td>
<td>Welded</td>
</tr>
<tr>
<td>services)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS [LP hydrocarbons (offsite)]</td>
<td>Up to 6&quot;</td>
<td>Seamless</td>
</tr>
<tr>
<td></td>
<td>Above 6&quot;</td>
<td>E.F.S.W /Welded</td>
</tr>
</tbody>
</table>

However, for HP steam and MP steam only seamless piping shall be used for all pipe sizes.

#### 6.3 Fittings

6.3.1 Type of fittings shall be equivalent to pipe type.

6.3.2 Thickness of fittings at ends to match pipe thickness for BW fittings.

6.3.3 SW fittings shall be 3000#, 6000# and 9000# depending on the pipe thicknesses S80, S160 and above S160 respectively.

6.3.4 All branch connections shall be as follows, unless specifically mentioned otherwise in PMS:

   - Up to 1-1/2" NB O-Lets/ Tee
   - 2" and above Tees/O-Lets / Pipe to pipe with or without Reinforcement pad up to 600# rating.
   - Only Teel Red tee/ sweepolets above 600# rating.
6.3.5 Mitred bends shall not be accepted unless otherwise specified. Only 90 Deg. elbows and 45 Deg. elbows are acceptable. In case the Bidder wants to deviate from this requirement the ground of non-availability of such forged items, bidder may submit an alternative offer for Owner's consideration with sufficient documents to justify the same. In such a case the concerned fittings shall be manufactured with necessary reinforcing pads, bend thinning allowance etc. to satisfy code requirements.

6.4 Flanges

Flanges shall be as follows.

<table>
<thead>
<tr>
<th>Rating (Lbs)</th>
<th>Size (NB)</th>
<th>Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>Up to 1.50&quot;</td>
<td>SW RF</td>
<td>If non metallic gasket used.</td>
</tr>
<tr>
<td></td>
<td>Up to 1.50&quot;</td>
<td>WN RF</td>
<td>If metallic gasket is used.</td>
</tr>
<tr>
<td></td>
<td>2&quot; &amp; above</td>
<td>WN RF/LJ FF</td>
<td>For SS LJ FF + Stub Ends</td>
</tr>
<tr>
<td></td>
<td>2&quot; &amp; above</td>
<td>SO FF/WN RF</td>
<td>If used in Cooling water, Fire water services</td>
</tr>
<tr>
<td>300,600</td>
<td>Up to 1.50&quot;</td>
<td>SW RF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2&quot; &amp; above</td>
<td>WN RF</td>
<td>except H2 SERVICE(*)</td>
</tr>
<tr>
<td>900,1500</td>
<td>All</td>
<td>WN RTJ</td>
<td></td>
</tr>
</tbody>
</table>

(*) For H2 service, use of WN RTJ flanges shall be as specified in PMS.

All flange joints on piping system including flanges on the equipment, manholes, etc shall be tightened using Torque wrench I hydraulic bolt tensioner depending upon service criticality.

6.5 Gaskets

<table>
<thead>
<tr>
<th>Rating (Lbs)</th>
<th>Material/service</th>
<th>Temperature (°C)</th>
<th>Type</th>
<th>Gasket or Strip Material + Filler Material/RTJ Gasket Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>CS &amp; SS (utilities)</td>
<td>Up to 371°C</td>
<td>Plain</td>
<td>Asbestos free</td>
</tr>
<tr>
<td>150</td>
<td>CS &amp;LTCS (other than utilities)</td>
<td>up to 371°C</td>
<td>Spiral Wound</td>
<td>SS316+</td>
</tr>
<tr>
<td>150</td>
<td>AS (all services)</td>
<td>up to 371°C</td>
<td>Spiral Wound</td>
<td>SS316+</td>
</tr>
<tr>
<td>300 &amp; 600</td>
<td>CS (all services, except H2)</td>
<td>up to 427°C</td>
<td>Spiral Wound</td>
<td>SS316+</td>
</tr>
<tr>
<td>300 &amp; 600</td>
<td>AS (all services, exceptH2)</td>
<td>above 371°C</td>
<td>Spiral Wound</td>
<td>SS316+Grafoil</td>
</tr>
<tr>
<td>150,300, 600</td>
<td>SS (other than utilities)</td>
<td>All</td>
<td>Spiral Wound</td>
<td>SS316+Grafoil (where trim material is SS304/316)''SS316+Grafoil (where trim material is SS304L1316L)</td>
</tr>
<tr>
<td>300(<em>), 600(</em>),900, 1500,2500</td>
<td>CS</td>
<td>All</td>
<td>Octagonal RTJ</td>
<td>Soft Iron</td>
</tr>
</tbody>
</table>
6.6 Valves

Type
a) SW Valves up to 1-1/2 inch - up to 600# except ball & plug valves which shall be flanged for all sizes.
b) Flanged cast valve above 1-1/2” for 150#, 300#, 600#
c) Welded Valves - 900# and above

6.7 Technical Requirements of Piping Items

Over and above the requirements specified in clause 6.1 through 6.6, other technical requirement prescribed in Annexure "4" shall also be adhered to.

6.8 NDT Requirements

Depending upon the severity of application, extent of NDT shall be decided. As a rule, all oxygen, NACE and any other lethal service shall have 100% radiography on weld joints in all class ratings. Castings used in these services shall have 100% radiography.

For normal hydrocarbon service upto class 600# shall be subjected to 20% radiography & 20% DP/ MP test (for CS&AS) and 20% radiography test as well as 100% DP test (for SS).

Classes in 900# and above for normal hydrocarbon service shall be subjected to 100% radiography test.

Note: 100% DP test to be carried out for all root welding.

For fire water service, IBR, etc., radiography shall be as per statutory requirement.

7.0 THERMAL INSULATION OF PIPING, EQUIPMENT & VESSELS

7.1 Hot Insulation

This consist of insulation for heat conservation, process stabilization, temperature maintenance, insulation for steam traced lines, jacketed lines, insulation for electrical traced lines insulation for fire protection for operating temperatures above ambient temperature for all sizes of lines. Wherever insulation for personnel protection is mentioned, the same shall be provided judiciously as per insulation specifications.
Preformed pipe sections shall be used for all sizes of piping and inspection windows shall be provided in insulation at critical locations to be decided at the time of execution.

All materials shall be of high quality and good appearance. Insulation materials shall be of low chloride content, chemically inert, non sulphurous, rot proof, vermin proof, impervious to hot water and steam, non-injurious to health and non-corrosive to steel and aluminium (even if soaked in 'water at ambient temperatures for extended periods). The use of insulation or finishing materials containing ASBESTOS in any form is not permitted.

The insulation of piping, equipments and vessels shall be carried out with the recommended insulating materials and the thicknesses as per process design basis. Hot insulation over austenitic stainless steel surfaces shall be inhibited with sodium silicate as per ASTM C-795. The inhibited insulation material shall be tested as per ASTM C-692. Restriction of reachable chloride to 10ppm (max,) shall be demonstrated as per the test method ASTM C-871. The specifications of different types of hot insulating materials shall be as follows:

### 7.1.1 Bonded Mineral Wool

Lightly resin bonded Rock wool insulation shall conform to ASTM C592 class II for blanket and ASTM C547 class III for preformed pipe sections. Rock wool insulation as per IS 8183 and IS 9842 are also acceptable. The material shall be suitable for intended operational temperature range from ambient to 550 degC. The physical requirement of bulk density and chloride content, thermal conductivity and PH value of the material shall be as follows:

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density</td>
<td>140-150 kg/m3</td>
</tr>
<tr>
<td>Chloride Content</td>
<td>20 ppm (max.)</td>
</tr>
<tr>
<td></td>
<td>10 ppm (max.) diffused over S.S surfaces.</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>0.43mW/cm°C for mean temp 50°C</td>
</tr>
<tr>
<td></td>
<td>0.52mW/cm°C for mean temp 100°C</td>
</tr>
<tr>
<td></td>
<td>0.62mW/cm°C for mean temp 150°C</td>
</tr>
<tr>
<td></td>
<td>0.68mW/cm°C for mean temp 200°C</td>
</tr>
<tr>
<td></td>
<td>0.80mW/cm°C for mean temp 250°C</td>
</tr>
<tr>
<td></td>
<td>0.90mW/cm°C for mean temp 300°C</td>
</tr>
<tr>
<td>PH Value</td>
<td>7.0 To 10.0</td>
</tr>
</tbody>
</table>

### 7.1.2 Calcium Silicate

Calcium Silicate block and pipe thermal insulation shall be composed principally of hydrous calcium silicate reinforced with mineral fibers (except slag wool).

The specification shall conform to ASTM C533 type-1 up to 550°C and as per ASTM C533 type-2 up to 760°C.

The physical requirement of bulk density, chloride content, thermal conductivity and ph value of the material shall be as follows:

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density</td>
<td>240 to 280 kg/m3</td>
</tr>
<tr>
<td>Chloride content</td>
<td>20 ppm (max) &amp; 10 ppm(max) if used over stainless steel.</td>
</tr>
</tbody>
</table>
7.1.3 Polyisocyanurate

Rigid Polyisocyanurate foam block pipe fittings insulation (Confirming to ASTM 591 TYPE II & III) shall be manufactured with polyester or polyether resins, flammability retarding agents, special catalysts and fluorocarbon blowing agent. This is suitable for use up to 125 deg C. Selection of samples for testing shall be as per ASTM C390 (Class IV frequency).

The physical requirement of bulk density, chloride content, thermal conductivity and PH value of the material shall be as follows:

- Bulk density 40 to 64 kg/m³ (Tested as per ASTM C303 and C302)
- Chloride content NIL
- Thermal Conductivity:
  - 0.238 mw/ Cm°C at mean temp 10 deg C
  - 0.245 mw/ Cm°C at mean temp 24 deg C
  - 0.252 mw/ Cm°C at mean temp 38 deg C
- PH Value: Neutral

7.1.4 Cellular Glass (Foam Glass)

Cellular glass foamed and fused into unicellular foam can be used up to temperature of 350°C. The testing of samples shall be as per ASTM C552. The physical requirement of bulk density, chloride content, thermal conductivity and PH value of the material shall be as follows:

- Bulk density 110 to 150kg/m3 (Tested as per ASTM C303)
- Chloride content NIL
- Thermal conductivity:
  - 0.58 mw/cm deg C at mean temp. 10°C
  - 0.60 mw/cm deg C at mean temp. 24°C
  - 0.62 mw/cm deg C at mean temp.38°C
  - 0.73 mw/cm deg C at mean temp. 93°C
- PH Value: Neutral.

7.2 Weather Protection Jacket (Cladding) - Hot Insulation

Aluminium jacketing shall be used as weather protection over insulation unless otherwise specified and shall be as per ASTM B 209 alloy 3003 H16 or IS: 737 designation 31000 (old NS3) condition H3 for flat sheets and H4 for corrugated sheets. Cladding shall be coated on the side in contact with bitumen anticorrosive paint. Where fire safe insulation material is required cladding and bands material shall be SS. The thickness of jacket shall be as follows:

<table>
<thead>
<tr>
<th>For Rock wool</th>
<th>For all materials other than Rock wool</th>
</tr>
</thead>
<tbody>
<tr>
<td>For shell of vertical vessels, columns etc:</td>
<td>0.71 mm (22SWG) corrugated</td>
</tr>
<tr>
<td>Storage tanks &amp; Tank Roofs</td>
<td>1.22mm (18SWG) Flat</td>
</tr>
<tr>
<td>For all piping, other than grade piping in off sites</td>
<td>0.71mm (22SWG) Flat</td>
</tr>
<tr>
<td>For Horton sphere &amp; horizontal vessels shell and heads, vertical vessel heads</td>
<td>0.71 mm (22SWG) Flat</td>
</tr>
<tr>
<td>For Removable covers</td>
<td>1.22 mm (18SWG) Flat.</td>
</tr>
<tr>
<td>For Reactors and reactor piping (extent and thickness shall be decided during execution)</td>
<td>SS JACKET</td>
</tr>
<tr>
<td>For grade piping in offsite</td>
<td>0.56 mm (24 SWG) Galvanized Steel per IS 277 or equivalent with a coating requirement of 450 gm/m2.</td>
</tr>
</tbody>
</table>

### 7.3 Ancillary Materials-Hot Insulation (Band, Wires, Screws, Etc.)

#### 7.3.1 Aluminium Foil to protect stainless surfaces in Temperature below 0 degCshall be 0.1 mm (42 SWG) thick per ASTM 8209 alloy 3003 H16 or IS-737 designation 31000 (OldNS3) condition H3.

#### 7.3.2 Bands/Wires for securing insulation shall be of ASTM 8209 Alloy 3003 H16 or 18-737 designation 31000 (old NS3) condition H3 or 18/8 Stainless steel. For securing aluminium foil on stainless steel surface 24 SWG thick x 20mm wide aluminium bands shall be used.

For securing fibrous insulation on piping, 24 SWG X 12 wide, aluminium bands shall be used.

For securing fibrous insulation on equipments, 24 SWG X 20 wide aluminium bands shall be used.

For securing fibrous material on vertical storage tank, galvanized steel 40 mm wide X 3 mm thick flat shall be used.

For securing fibrous material on spheres, stainless steel bands of 25 mm wide X 0.8 mm thick shall be used.

For securing Rigid Insulation on piping up to 16” O.D., annealed galvanized steel wire of 16 SWG shall be used. Galvanizing coating shall have 450g/m2 of surface area.

For securing rigid insulation on pipe 18” O.D., and above, galvanized steel band 20 mm wide X 24 SWG shall be used. Galvanizing shall be 600 g/m2 of surface area.

For securing rigid insulation on vertical and horizontal vessels, galvanized steel band 20mm wide X 24 SWG shall be used. Galvanizing shall be 450g/m2 of surface area.

Screws required for metal jacket security shall be of Stainless Steel.

#### 7.3.3 For securing cladding on insulation on piping, aluminium band 12mm (min) X 24 SWG thick shall be used.

For securing cladding on insulation on equipment, aluminium band 20mm wide X 24 SWG shall be used.

For securing cladding on insulation for vertical storage tanks stainless steel band 25mm wide X 24 SWG shall be used.
For securing cladding on insulation for spheres stainless steel band 25mm wide X 24 SWG shall be used.

7.3.4 Rivets used for security of metal jacket shall be expanding aluminium "POP" blind eye type; 9.5 mm long x 5mm diameter.

7.4 Cold Insulation

Insulation material and specifications for cold insulation for operating temperatures up to (-)180°C and dual temperature (cold/hot) service where, upper temperature limit is 125°C shall be as given below for all sizes of piping:

7.4.1 Polyurethane Foam

Preformed pipe section's and radial lags (for higher diameter pipe) of polyurethane foam of self extinguishing type shall be in accordance with ASTM C591 TYPE-II Grade 2. The physical requirement of bulk density, chloride content, thermal conductivity and PH value of the material shall be as follows:

<table>
<thead>
<tr>
<th>Temp. Limit Bulk density</th>
<th>Up to (-)180°C &amp; 120°C (max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride content</td>
<td>20 ppm (max)</td>
</tr>
<tr>
<td>Thermal conductivity</td>
<td>0.221 mw/cm˚C Cat mean temp. 10 deg C</td>
</tr>
<tr>
<td>PH Value</td>
<td>Neutral.</td>
</tr>
<tr>
<td>Closed cell content</td>
<td>95% (min)</td>
</tr>
</tbody>
</table>

High density polyurethane foam block of bulk density more than 300 Kg/m³ shall be used for supports in cold lines.

7.4.2 Polyurethane Foam Cast-in-Situ

Temp. Limit : Up to (-) 45°C and 120°C (max.)

For specification, refer Clause 7.4.1 above and for application procedure Contractor shall secure OWNER/PMC approval.

7.4.3 Polyisocynaurate

Temp. Limit : Up to (-) 180°C and 125°C (max.)

Refer Clause 7.1 c) for details.

Ancillary materials and cladding for cold insulation shall be as follows:

Adhesive for bonding sections shall be Foster Fire Resistive Adhesive 81-33 or blown bitumen type 85/25 shall be used.

Vapor seal like Foster Fire Retardant Mastic 60-30 or equal shall be used.

Filler material shall be PUF dust or mineral wool mixed with specified adhesive shall be placed lightly so as to fill irregular voids and sealant shall be Foster Foam Seal Sealer 30-45. Glass cloth to be used for vapor barrier reinforcement shall be open weave 10 mesh having glass fiber thickness of 5 mils. Aluminium sheets as follows shall be used for cladding.

<table>
<thead>
<tr>
<th>Application</th>
<th>Minimum Sheet Gauge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipes, vessels and equipments</td>
<td>26 SWG</td>
</tr>
<tr>
<td>Up to 500 mm nominal diameter</td>
<td>24 SWG</td>
</tr>
<tr>
<td>Pipes ,vessels and equipments</td>
<td></td>
</tr>
</tbody>
</table>
above 500 mm nominal diameter

For valves, flanges and other areas where mechanical change is likely to occur.

Where fire safe insulation is required cladding and bands material shall be SS.

7.5 **Insulation Thickness**

The insulation thickness and type of insulation (hot, cold and acoustics) to be applied on equipments and vessels shall be as per equipment data sheet.

Insulation thickness on piping shall be as per final approved line list / line schedule / insulation table in process design basis.

7.6 **Extent of Insulation**

Extent of insulation shall be as per final approved P&ID / Line list / General Arrangement drawing / Isometrics and vessel and equipment data sheets.

Insulated piping system shall have straight pipe, bends, tees and pipe fittings completely insulated.

For all cold lines, all steam and condensate lines, all hot oil lines and trace heated & jacketed lines, the extent of insulation shall include valves and flange joints also.

For bucket and float type traps the inlet piping and trap shall be insulated.

For thermostatic and thermodynamic traps insulation shall terminate at approx. 150 mm before trap.

Instrumentation such as level gauges, level controllers, level switches, DP cells, etc., shall have their fluid containing sections and associated piping completely insulated.

In case of hot insulation system, insulation shall not be applied to the following unless specifically asked otherwise.

a) Valves, including control valves, flanges in process lines below 300 °C (Safety insulation shall be provided wherein required)

b) Pipe union fittings.

c) Steam Traps, sight flow indicators.

d) Steam trap outlet piping other than closed condensate recovery system except for personal protection reasons.

e) Pumps with operating temp below 200 °C

f) Fans, compressors, blower or other rotating or reciprocating equipments.

g) Internally insulated or refractory lined equipment.

h) Turbine seal caps, shaft bearing housing, throttle valves, governors and supports.

i) Exchanger channel and covers, shell and channel flanges and expansion joints.

j) Nozzles, manholes and hand holds and flanges of equipment.

k) Surfaces of coolers and condensers.

l) Thermo well bosses and pressure tapings.
7.7 Application

All insulation work shall commence only after successful completion of hydro testing of piping and equipments including steam tracing systems. Surfaces to be insulated shall be thoroughly cleaned, dried and made free from loose scale, oil or grease. Painting under insulation shall be applied to carbon steel, low alloy steel, except stainless steel piping and equipments.

No welding or drilling of equipments and piping shall be permitted for insulation application.

All projections, such as lifting lugs, trunnion, support lugs, support cleats shall be insulated to the same extent that of equipment or piping.

Cleats used for supporting of insulation shall not project outside insulation.

Insulation windows for inspection thickness survey are to be provided for insulated equipment and piping (piping size 4” NB and above) for 20% of bend locations. However for transfer lines the insulation windows shall be provided at all bend locations.

To ensure perfect water proofing, all cladding joints shall be packed with sealing materials which may either be in the form of an elastomeric sealing compound or fibre based bituminous felt strips.

Minimum overlap in sheet metal at joints shall be 100 mm.

Support skirts of vertical vessels and columns shall be insulated both from inside and outside to a minimum distance of 600 mm from bottom tangent line. The insulations must terminate at minimum 300 mm above support concrete or steel work.

Tank shell insulation shall have continuity in insulation cladding even at stiffener retainer ring location on shell.

Proper expansion/contraction joints shall be provided to allow movement of pipe or vessel without producing random cracking of all the insulation.

Vapour barrier shall be applied on piping and all the vessels & equipments in cold services and also for services up to 125 °C.

8.0 Painting

8.1 Scope of Painting

8.1.1 The following surfaces and materials shall require painting:

a) All un-insulated C.S & A.S piping, fittings, valves, columns, vessels, drums, & storage tanks, heat exchangers etc. including painting of identification marks on insulated lines.

b) Identification color bands on all piping as required including insulated aluminium clad, galvanized, SS and non ferrous piping.

c) Pipes, fittings & valve surfaces under insulation of carbon steel and alloy steel insulated piping system.

d) Pipes, fittings, valves surfaces under insulation of stainless steel insulated piping system.

e) All structural steel works, supports, walkways, handrails and platforms etc.

8.1.2 The following surfaces and materials shall not require painting:

a) Un-insulated austenitic stainless steel and higher alloy piping.
b) Plastic and plastic coated materials.
c) Non ferrous material like aluminium, galvanized, brass, bronze piping etc.

8.2 Color Coding
Painting work shall require satisfying the requirements of the area where the plant is being setup. All painting and color coding shall be as per local painting manual.

8.3 Surface Preparation
As per local specification

8.4 Painting Application
As per local specification

8.5 Painting Materials
As per local specification

9.0 WELDING

9.1 Applicable Codes & Standards
All welding work, equipment for welding, heat treatment, other auxiliary functions and the welding personnel shall meet the requirements of the latest editions of the following accepted standards and procedures.

a) Power Piping ASME: B31.1
b) The Indian Boiler Regulations IBR.

In addition, the following codes and specifications referred in the code of fabrication shall be followed for the welding specifications, consumable qualifications and non destructive test procedures.

i) Welding and Brazing Qualifications ASME BPV- Sec. IX.
ii) Non destructive examination ASME BPV Sec. V.
iii) Material specifications: Welding rods, electrodes and filler metals ASME BPV Sec II Part C.

The additional requirements mentioned in this specification, over and above those obligatory as per codes, shall be followed wherever specified.

9.2 Welding Processes
9.2.1 Welding of various materials shall be carried out using one or more of the following processes with the approval of OWNER / PMC.
- Shielded Metal Arc Welding process (SMAW)
- Gas Tungsten Arc Welding process (GTAW).

9.2.2 Automatic and semi-automatic welding processes shall be employed only with the express approval of the OWNER / PMC. The welding procedure adopted and consumables used shall be specifically approved.

9.2.3 A combination of different welding processes could be employed for a particular joint only after duly qualifying the welding procedure to be adopted and obtaining the approval of OWNER/ PMC.
## TABLE OF BASIC SPAN

<p>| Pipe Size In. NB | Sch/t hk (in) | Pipe- Vapor Insulation | | | | Pipe- Liquid Insulation | | | | | | BARE PIPE EMPTY | | | | | | BARE PIPE WATER FILLED | | | | | | Pipe size in. |
| 3/4&quot; | SCH 40 | 3.5 | 3.5 | 2.5 | 3.5 | 3.0 | 2.0 | 4.5 | 1.68 | 4.0 | 2.04 | 3/4&quot; |
| 1&quot; | SCH 40 | 4.5 | 4.0 | 3.0 | 4.5 | 3.5 | 3.0 | 5.0 | 2.52 | 4.5 | 3.07 | 1&quot; |
| 1-1/2&quot; | SCH 40 | 5.0 | 5.0 | 4.5 | 5.0 | 4.5 | 3.5 | 6.0 | 4.08 | 5.0 | 5.4 | 1-1/2&quot; |
| 2&quot; | SCH 40 | 5.5 | 5.0 | 4.5 | 5.0 | 4.5 | 3.5 | 8.5 | 5.47 | 5.5 | 7.65 | 2&quot; |
| 3&quot; | SCH 40 | 7.5 | 6.5 | 5.5 | 6.5 | 6.0 | 5.0 | 8.0 | 11.35 | 6.5 | 16.15 | 3&quot; |
| 4&quot; | SCH 40 | 8.0 | 7.5 | 6.5 | 7.5 | 7.0 | 6.0 | 9.0 | 16.2 | 7.5 | 24.45 | 4&quot; |
| 6&quot; | SCH 40 | 10.0 | 9.5 | 8.5 | 9.0 | 8.0 | 7.5 | 10.5 | 28.3 | 9.0 | 46.7 | 6&quot; |
| 8&quot; | SCH 40 | 12.0 | 11.0 | 10.0 | 10.0 | 10.0 | 9.0 | 12.0 | 42.84 | 10.0 | 75.22 | 8&quot; |
| 10&quot; | SCH 40 | 13.5 | 13.0 | 12.0 | 11.5 | 10.5 | 10.5 | 14.0 | 60.74 | 11.5 | 111.9 | 10&quot; |
| 12&quot; | 3/8&quot; w | 14.5 | 13.5 | 13.0 | 12.0 | 11.5 | 11.0 | 15.0 | 74.40 | 12.0 | 147.5 | 12&quot; |
| 14&quot; | 3/8&quot; w | 15.0 | 14.5 | 13.5 | 12.0 | 12.0 | 11.5 | 16.0 | 82.5 | 12.5 | 172.05 | 14&quot; |
| 16&quot; | 3/8&quot; w | 16.0 | 15.5 | 14.5 | 13.0 | 12.5 | 12.0 | 17.0 | 94.5 | 13.0 | 213.15 | 16&quot; |
| 18&quot; | 3/8&quot; w | 17.0 | 16.5 | 15.0 | 13.5 | 13.0 | 12.0 | 18.0 | 106.5 | 13.5 | 258.3 | 18&quot; |
| 20&quot; | 3/8&quot; w | 18.0 | 17.5 | 16.0 | 14.0 | 13.5 | 12.5 | 19.0 | 118.5 | 14.0 | 307.5 | 20&quot; |
| 24&quot; | 3/8&quot; w | 20.0 | 19.0 | 17.5 | 14.5 | 14.5 | 13.0 | 21.0 | 1425 | 15.0 | 418.2 | 24&quot; |
| 3/4&quot; | SCH 80 | 3.5 | 3.5 | 2.5 | 3.5 | 3.0 | 2.0 | 4.5 | 2.20 | 4.0 | 2.49 | 3/4&quot; |
| 1&quot; | SCH 80 | 4.5 | 4.0 | 3.0 | 4.5 | 3.5 | 3.0 | 5.0 | 3.25 | 4.5 | 3.72 | 1&quot; |
| 1-1/2&quot; | SCH 80 | 5.0 | 5.0 | 4.5 | 5.0 | 4.5 | 4.0 | 6.0 | 5.45 | 5.0 | 6.60 | 1-1/2&quot; |
| 2&quot; | SCH 80 | 6.0 | 5.0 | 4.5 | 5.5 | 5.0 | 4.0 | 6.5 | 7.53 | 6.0 | 9.45 | 2&quot; |
| 3&quot; | SCH 80 | 7.5 | 6.5 | 6.0 | 6.5 | 6.5 | 6.0 | 8.0 | 15.37 | 7.0 | 19.66 | 3&quot; |</p>
<table>
<thead>
<tr>
<th>Pipe Size In. NB</th>
<th>Sch/t hk (in)</th>
<th>PIPE- VAPOR INSULATION</th>
<th>PIPE- LIQUID INSULATION</th>
<th>BARE PIPE EMPTY</th>
<th>BARE PIPE WATER FILLED</th>
<th>Pipe size in.</th>
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<td>BASIC SPAN (L)M</td>
<td>BASIC SPAN (L)M</td>
<td>SPA N(L) M</td>
<td>WEIGHT KG/M</td>
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<td>176°C to 315°C</td>
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<td>Pipe Size In. NB</td>
<td>Sch/t hk (in)</td>
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<td>BARE PIPE EMPTY</td>
<td>BARE PIPE WATER FILLED</td>
<td>Pipe size in.</td>
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## ACCESSIBILITY FOR VALVES AND INSTRUMENTS

<table>
<thead>
<tr>
<th>VALVES, INSTRUMENTS, EQUIPMENT TO BE OPERATED</th>
<th>CENTRELINE OF ITEM TO BE OPERATED, LOCATED LESS THAN 3.6m ABOVE GRADE, 2.75m ABOVE FLOOR OR PLATFORM OR 1.8m ABOVE WING PLATFORM</th>
<th>CENTRELINE OF ITEM TO BE OPERATED, LOCATED MORE THAN 3.6m ABOVE GRADE, 2.75m ABOVE FLOOR OR PLATFORM OR 1.8m ABOVE WING PLATFORM</th>
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<tr>
<td>EXCHANGER HEADS</td>
<td>NIL</td>
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</tr>
<tr>
<td>OPER. VALVES 2” &amp; SMALLER</td>
<td>-FIXED Ladder</td>
<td>FIXED Ladder</td>
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<tr>
<td>OPER. VALVES 3” &amp; ABOVE</td>
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<td>MOTOR OPERATED VALVES</td>
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<td>CONTROL VALVES</td>
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<td>RELIEF VALVES 2” &amp; SMALLER</td>
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<td>BLOCK VALVES 2” &amp; SMALLER</td>
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<td>BLOCK VALVES 3” &amp; ABOVE</td>
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<td>BATTERY LIMIT VALVES</td>
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<tr>
<td>PRESSURE INSTRUMENT</td>
<td>FIXED Ladder IF ABOVE 2.2m HEIGHT</td>
<td>FIXED Ladder</td>
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<td>TEMPERATURE INSTRUMENT</td>
<td>FIXED Ladder IF ABOVE 2.2m HEIGHT</td>
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<td>GAUGE GLASSES</td>
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<td>LEVEL CONTROLLERS</td>
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<td>PROCESS BLINDS AND SPACERS 2” &amp; SMALLER</td>
<td>PORTABLE Ladder / PLATFORM</td>
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<tr>
<td>PROCESS BLINDS AND SPACERS 3” &amp; ABOVE</td>
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<td>LINE DRAINS &amp; VENTS</td>
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<td>ORIFICE FLANGES</td>
<td>PORTABLE Ladder</td>
<td>FIXED Ladder-(NOTE 2)</td>
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</tbody>
</table>

**NOTE -1:** BLOCK VALVES, IF LOCATED, WITH CENTRE LINES 2.0 m ABOVE FROM THE OPERATING FLOOR! PLATFORM SHALL BE PROVIDED WITH PORTABLE PLATFORM OR CHAIN FOR OPERATION OF VALVES.

**NOTE -2 :** PLATFORM SHALL BE PROVIDED FOR THE ORIFICE FLANGES ON PIPE RACK.
### ANNEXURE-3

**MAXIMUM SPACING OF GUIDES FOR VERTICAL & HORIZONTAL PIPES**

<table>
<thead>
<tr>
<th>NOM PIPE SIZE IN INCHES</th>
<th>VERTICAL SPACING METRES</th>
<th>HORIZONTAL SPACING METRES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>1 ½</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>2</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>3</td>
<td>8.0</td>
<td>12.0</td>
</tr>
<tr>
<td>4</td>
<td>8.0</td>
<td>12.0</td>
</tr>
<tr>
<td>6</td>
<td>8.0</td>
<td>12.0</td>
</tr>
<tr>
<td>8</td>
<td>8.0</td>
<td>12.0</td>
</tr>
<tr>
<td>10</td>
<td>12.0</td>
<td>18.0</td>
</tr>
<tr>
<td>12</td>
<td>12.0</td>
<td>18.0</td>
</tr>
<tr>
<td>14</td>
<td>12.0</td>
<td>18.0</td>
</tr>
<tr>
<td>16</td>
<td>12.0</td>
<td>18.0</td>
</tr>
<tr>
<td>18</td>
<td>12.0</td>
<td>18.0</td>
</tr>
<tr>
<td>20</td>
<td>16.0</td>
<td>18.0</td>
</tr>
<tr>
<td>24</td>
<td>16.0</td>
<td>18.0</td>
</tr>
<tr>
<td>26 &amp; ABOVE</td>
<td>16.0</td>
<td>18.0</td>
</tr>
</tbody>
</table>

**NOTES:-**

1.0 These spacings may be varied to suit column spacing of rack. The above spacing is for straight runs of pipe & does not include guides which are used for control of thermal movements, as decided by stress group.

2.0 The guide spacings given in the above table are indicative only.
TECHNICAL REQUIREMENTS OF PIPING ITEMS

1.0 ENDS

Unless otherwise specified in PMS, the ends of piping items shall be to the following standards:

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW/SCRD</td>
<td>ASME B 16.11</td>
</tr>
<tr>
<td>BW</td>
<td>ASME B16.25</td>
</tr>
<tr>
<td>FLANGED</td>
<td>ASME B16.5 and ASME B16.47 SERIES 'B'/API-605</td>
</tr>
<tr>
<td>THREADING</td>
<td>ASME/ANSI B1.20.1 (NPT, Taper threads)</td>
</tr>
</tbody>
</table>

1.1 Face Finish

The face finish of flanges/flanged items shall be to MSS-SP-6/ASME B 46.1 / ASME B16.5. The interpretation shall be:

- **Stock Finish**: 250-1000 μ in AARH
- **Serrated Finish/125 AARH**: 125-250 μ in AARH
- **Smooth Finish/63 AARH**: 32-63 μ in AARH

1.2 Austenitic Stainless Steel

All items/parts shall be supplied in solution annealed condition.

For all Austenitic Stainless steels, Inter granular Corrosion' (IGC) Test shall be conducted as per following:

- **ASTM A262 Practice 'B'**: with acceptance criteria of 60 mils/year (max.) for casting.
- **ASTM A262 Practice 'E'**: with acceptance criteria of 'No cracks as observed from 20 X magnification & microscopic structure to be observed from 250 X magnification for other than casting.

For IGC test, two sets shall be drawn from each solution annealing lot; one set corresponding to highest carbon content and other set corresponding to the highest rating/thickness.

For all items of stabilized SS grades, resolution annealing shall be done. It shall be carried out subsequent to normal resolution annealing. Soaking temperature and holding time for stabilizing heat treatment shall be 900 deg. Celsius and four hours respectively.

2.0 ITEM SPECIFIC NOTES

2.1 Pipes

- Unless specifically exempted, welded pipes shall be acceptable only with longitudinal weld made employing automatic welding.
- Double longitudinal seam 180˚ apart is allowed for sizes 36" NB and larger only.
- Galvanized Pipes shall be only Hot Dip galv. to ASTM A53.
- Alloy steel Pipes shall be Normalized and tempered.

2.2 Fittings

- All fittings shall be as per specified in PMS.
• For reducing BW fittings having different wall thicknesses at each end, the greater one shall be employed and the ends shall be matched to suit respective thickness.

• All welded fittings shall have maximum negative tolerance equivalent to pipe selected.

• All welded fittings shall be double welded for size 16” NB & above. Inside weld projection shall not exceed 1.6mm, and the welds shall be ground smooth at least 25mm from the ends.

• For fittings made out of welded pipe, the pipe itself shall be of double welded type, manufactured with the addition of filler material and made employing automatic welding only.

• All welded fittings shall be normalized for CS, normalized & tempered for AS; and 100% radiographed by X-ray for all welds made by fitting manufacturer as well as for welds on the parent material.

• Bevel ends of all BW fittings shall undergo 100% MP/DP test except utility services.

2.3 Flanges

• For Ring Joint Flanges, Blinds and Spacers, the hardness shall be as follows:

<table>
<thead>
<tr>
<th>Flange Material</th>
<th>Min. Hardness of Groove (BHN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Steel</td>
<td>120</td>
</tr>
<tr>
<td>1% Cr to 5% Cr, 1/2 Mo</td>
<td>150</td>
</tr>
<tr>
<td>Type 304, 316, 347, 321</td>
<td>160</td>
</tr>
<tr>
<td>Type 304L, 316L</td>
<td>140</td>
</tr>
</tbody>
</table>

• For RTJ flanges, blinds & spacers, the hardness of the groove shall be specified on the test report.

• Bore of weld neck flange shall correspond to the inside diameter of pipe for specified schedule/thickness. Ends shall be beveled to suit the specified schedule/thickness.

• For RTJ flanges, only octagonal section ring joint flanges shall be used.

2.4 Valves

• Valves of Class 900 & above shall be pressure-seal type.

• Threaded and seal welded or welded bonnet shall be employed up to sizes 1-1/2” for valves of class 900# rating & above.

• All flanged valves (except forged) shall have flanges integral with the valve body.

• Valve Castings/Forgings purchased shall be from Local approved foundries/forging shop.

• Yoke material shall be at least equal to body material.

• Forgings are acceptable in place of Castings but not vice-versa.

• No cast iron valves to be used in firewater or any other service.

• Valves in sea water service shall be with non ferrous trims and all wetted parts other than trims shall be epoxy coated.

2.4.1 Dimensions

• Face-to-Face/End-to-End dimension shall be as per ANSI B16.10. In case the same is not covered under B16.10, the dimension shall be as per BS 2080/manufacturer standard.
- Valve under cryogenic service (temp. below -45°C) shall be as per BS-6364 and shall be procured from pre-qualified vendor.
- Generally the valves are hand wheel or lever operated. However, suitable gear operator in enclosed gear box shall be provided for valves as follows:

Gears operators shall be specified for gate, globe, angle, ball, butterfly and plug valves as follows:

<table>
<thead>
<tr>
<th>Gate Valves:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CL150</td>
<td>14&quot;NPS and larger</td>
</tr>
<tr>
<td>CL300</td>
<td>10&quot;NPS and larger</td>
</tr>
<tr>
<td>CL600 &amp; 900</td>
<td>8&quot;NPS and larger</td>
</tr>
<tr>
<td>CL1500 &amp; CL2500</td>
<td>3&quot;NPS and larger</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Globe and Angle Valves:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CL150</td>
<td>12&quot;NPS and larger</td>
</tr>
<tr>
<td>CL300</td>
<td>8&quot;NPS and larger</td>
</tr>
<tr>
<td>CL600</td>
<td>6&quot; NPS and larger</td>
</tr>
<tr>
<td>CL900</td>
<td>4&quot; NPS and larger</td>
</tr>
<tr>
<td>CL1500 &amp; 2500</td>
<td>3&quot; NPS and larger</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ball Valves:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CL150 to 300</td>
<td>8&quot; NPS and larger</td>
</tr>
<tr>
<td>CL600</td>
<td>8&quot;NPS and larger</td>
</tr>
<tr>
<td>CL900 to 1500</td>
<td>3&quot; NPS and larger</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Butterfly Valves:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CL150 to 600</td>
<td>8&quot;NPS and larger</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plug Valves:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CL150 to 600</td>
<td>6&quot; NPS and larger</td>
</tr>
</tbody>
</table>

Spectacle blinds and paddle blinds/spacers shall be provided per the pressure class and size range divisions shown below:

<table>
<thead>
<tr>
<th>Spectacle Blind</th>
<th>Paddle Blind/Spacer</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL150 14&quot;NPS and below</td>
<td>CL150 16&quot;NPS and above</td>
</tr>
<tr>
<td>CL300 10&quot; NPS and below</td>
<td>CL300 12&quot;NPS and above</td>
</tr>
<tr>
<td>CL600 8&quot; NPS and below</td>
<td>CL600 10&quot;NPS and above</td>
</tr>
</tbody>
</table>

- Hand wheel diameter shall not exceed 750mm and lever length shall not exceed 500 mm on each side. Effort to operate shall not exceed 35 kgf at hand wheel periphery. However, failing to meet the above requirement, vendor shall offer gear operation.
- Quarter-turn valves shall have "open" position indicators with limit stops.
2.4.2 By-Pass

- A globe type valve (size as per ASME/ANSI B16.34) shall be provided as by-pass for the following sizes of gate valves:

<table>
<thead>
<tr>
<th>Class</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>26'' &amp; above</td>
</tr>
<tr>
<td>300</td>
<td>16'' &amp; above</td>
</tr>
<tr>
<td>600</td>
<td>6'' &amp; above</td>
</tr>
<tr>
<td>900</td>
<td>4'' &amp; above</td>
</tr>
<tr>
<td>1500</td>
<td>4'' &amp; above</td>
</tr>
<tr>
<td>2500</td>
<td>3'' &amp; above</td>
</tr>
</tbody>
</table>

- By-pass Piping, Fitting and Valves shall be of compatible material and design. Complete fillet welds for by-pass installation shall be DP/MP tested.

NDT of by-pass valve shall be in line with main valve.

2.4.3 Radiography of Cast Valves

- Quantity is considered for each size in each valve sheet.
- Radiography procedure, areas of casting to be radiographed, and the acceptance criteria shall be as per ASME/ANSI B16.34.
- All valve castings shall be of radiographic quality.
  a) The minimum requirement of radiography for service shall be as under:

<table>
<thead>
<tr>
<th>Class</th>
<th>Size</th>
<th>qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>UP TO 24</td>
<td>5%</td>
</tr>
<tr>
<td>150</td>
<td>26&quot; &amp; above</td>
<td>100%</td>
</tr>
<tr>
<td>300</td>
<td>UP TO 16</td>
<td>10%</td>
</tr>
<tr>
<td>300</td>
<td>18&quot; &amp; above</td>
<td>100%</td>
</tr>
<tr>
<td>600</td>
<td>All</td>
<td>100%</td>
</tr>
<tr>
<td>900 &amp; above</td>
<td>All</td>
<td>100%</td>
</tr>
</tbody>
</table>

b) Additional radiography requirement for casting sizes for special critical piping classes (Over and above the requirements covered in clause (a) above) shall be as follows:

c)
  i) For hydrogen / hydrogen bearing, oxygen, NACE, stress relieved caustic services:

<table>
<thead>
<tr>
<th>Class</th>
<th>Size</th>
<th>qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>up to 24&quot;</td>
<td>50%</td>
</tr>
<tr>
<td>150</td>
<td>ABOVE 24&quot;</td>
<td>100%</td>
</tr>
<tr>
<td>300</td>
<td>up to 16&quot;</td>
<td>50%</td>
</tr>
<tr>
<td>300</td>
<td>ABOVE 16&quot;</td>
<td>100%</td>
</tr>
</tbody>
</table>

  ii) For LT / CRYO services:
### 2.4.4 Ball/Plug/Butterfly Valves

- Each valve shall be supplied with a lever/wrench except for gear operated/motor operated valves.
- Soft-seated Ball, Plug & Butterfly valves shall be supplied with antistatic devices.
- The ball of Ball valves shall not protrude outside the end flanges.
- Ball valves shall be floating ball type / trunnion mounted type as per following:

<table>
<thead>
<tr>
<th>Class</th>
<th>Size</th>
<th>qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>up to 24&quot;</td>
<td>10%</td>
</tr>
<tr>
<td>150</td>
<td>ABOVE 24&quot;</td>
<td>100%</td>
</tr>
<tr>
<td>300</td>
<td>up to 16&quot;</td>
<td>10%</td>
</tr>
<tr>
<td>300</td>
<td>ABOVE 16&quot;</td>
<td>100%</td>
</tr>
</tbody>
</table>

iii) For alloy steel & stainless steel castings (Not covered in paras a, b(i) & b(ii):

<table>
<thead>
<tr>
<th>Class</th>
<th>Size</th>
<th>qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>up to 24&quot;</td>
<td>20%</td>
</tr>
<tr>
<td>150</td>
<td>ABOVE 24&quot;</td>
<td>100%</td>
</tr>
<tr>
<td>300</td>
<td>up to 16&quot;</td>
<td>20%</td>
</tr>
<tr>
<td>300</td>
<td>ABOVE 16&quot;</td>
<td>100%</td>
</tr>
</tbody>
</table>

#### 2.4.5 Special Valves (Orbit. Y -body Globe, Jacketed, Valves of all types)

- SPECIAL VALVES shall strictly follow the requirements of Valve data sheet, Process data sheet/Specialty data sheet.
- Special Valves shall be made out of 100% radiographic casting/ 100% ultrasound forging.
- Jacketed Valves shall be tested to 100% DP/ MP check on Jacket welding, 100% radiography test of valve body, 100% hydro test of Jacket.

#### 2.5 Strainer

- Allowable pressure drop when specified shall be certified by vendor along with the offer. If asked specifically, vendor shall furnish pressure drop calculations.
- All 2" & higher sized Y type strainers shall be provided with 3/4" threaded, tap and solid threaded plug as drain connection. For less than 2", this shall be ½" size.
- Bottom flange of Y-type strainer shall not have tapped hole. Full length standard size studs shall be used for joining blind flange.
2.6 Traps

- For fabricated strainers, all BW joints shall be fully radiographed and fillet welds shall be 100% DP/MP checked.
- All the strainers shall be hydrostatically tested at twice the design pressure.

- Vendor shall also furnish the performance curve indicating the capacity in mass/hour at various differential pressures across the trap.
- Parts subject to wear and tear shall be suitably hardened. Traps shall function in horizontal as well as in vertical installation.
- Traps shall have integral strainers.
- All traps shall be hydrostatically tested to twice the design pressure.

2.7 Hoses

- Manufacturer shall guarantee suitability of hoses for the service and working conditions specified in the requisition, if the material is not specified in the Material Requisition for any particular service.
- All hoses shall be marked with service and working pressure at minimum two ends clearly.
- Hoses shall be resistant to ageing, abrasion and suitable for outdoor installations.
- Complete Hose assembly shall be tested at two times the design pressure.
- Steam hoses shall be subject to steam resistance test.

2.8 Expansion Joints

- The applicable codes are ASME B31.1 and EJMA (Expansion Joint Manufacturer's Association).
- Bellows shall be formed from solution annealed sheet conforming to the latest ASTM Spec. Any longitudinal weld shall be 100% radiographed. The finished longitudinal weld must be of the same thickness and same surface finish as the parent material.
- Circumferential welds are not permitted. Bellows are to be hydraulically or expansion (punched) formed. Rolled formed bellows are not acceptable. Noticeable punch or die marks resulting from expansion operation are not acceptable.
- No repairs of any kind are allowed on the bellows after forming. Deep scratches and dents are not acceptable.
- The out of roundness shall be limited to ± 3mm. This is the max. deviation between the max. & min. diameter.
- The actual circumference of the welding end shall be maintained to ± 3mm of the theoretical circumference.
- Apart from the usual requirements, the vendor shall also furnish
  a) Design calculations to justify stiffness and fatigue life.
  b) Axial, lateral stiffness, angular stiffness, effective pressure thrust area.
  c) Installation/maintenance manual.

2.9 Supports & Spring Assemblies

- The Material, Design, Manufacture and Fabrication shall be generally as per MSS-SP-58/ MSS-SP-89 and/or BS 3974.
- Testing of springs shall be as per BS1726.
2.10 Gaskets

- Non-asbestos filler for spiral wound gasket shall not have any color or dye.
- Full face gaskets shall have bolt holes punched out.
- Non-metallic ring gaskets as per ASME/ANSI B16.21 shall match flanges to ASME/ANSI B16.5 up to 24", and ASME/ANSI B16.47 or AWWA for sizes> 24" unless otherwise specified.
- Spiral wound gaskets as per ASME B16.20 shall match flanges to ASME/ANSI B16.5 up to 24", and ASME B16.47 series 'B' for sizes> 24" unless otherwise specified.
- Inner and outer rings requirement for spiral wound gaskets shall be as per PMS General notes.
- Inner ring shall be provided for the following:
  a) As per code. (B 16.20) requirement.
  b) For sizes 26" & above in all classes.
  c) For vacuum and hydrogen service.
  d) For SS321, SS347 and H grade SS classes.
  e) For classes where temperature is higher than 427°C.
  f) For 900# rating and above classes.
- In case of RTJ gaskets, only octagonal section ring gaskets shall be used & shall have proper marking stamped. Material certificate shall be available for the gasket.
- Hardness of RJT shall be 20 BHN (min) less than the corresponding flange groove hardness.

2.11 Stud, Bolts, Nuts and Jack Screws

- All bolting shall be as per ASME/ANSI B18.2.1 for Studs, M/C Bolts and Jack screws, and ASME/ANSI B18.2.2 for nuts.
- Threads shall be unified (UNC for; 1" dia and 8-UN for> 1" dia) as per ANSI B1.1 with class 2A fit for Studs, M/C Bolts and jack screws, and class 2B fit for nuts.
- Stud bolts shall be threaded full length with two heavy hex nuts. Length tolerance shall be in accordance with the requirement of table F2 of Annexure 6 of ASME B16.5
- The nuts shall be double chamfered, semi-finished, heavy hexagonal type and shall be made by the hot forged process.
- The length of the studs/bolts should be such that minimum two threads should be out of the nut on either side.
- The entire stud bolt should have metallurgical certificates in case of Alloy/ SS metallurgy with identified color marking at the stud ends/ bolt side face.
- In corrosive atmosphere like Acid chemical storage area, cooling towers area, where SS flanges are provided, fasteners should also be SS.
- Heads of jack screws and M/C bolts shall be heavy hexagonal type. Jack screw end shall be rounded.
- Wherever bolt tensioning is specified stud bolt length shall be longer by minimum one diameter do suit bolt tensioner. Excess threads shall be protected by a threaded cap.
3.0 SPECIAL SERVICE REQUIREMENTS

3.1 IBR
IBR stands for Indian Boiler Regulation. For steam services, it is statutory obligation to meet IBR requirements.
For items under purview of IBR, composition restrictions, test reports, painting, etc. shall be as per IBR's stipulations.

3.2 NACE & Sour Service
For items under this category, unless otherwise specified in PMS, NACE-: MR-01-75 shall be followed. Hardness shall be below BHN 200 for C.S. material. Carbon equivalent (CE) shall be limited to 0.43.

3.3 CRYO & Fire-Safe
For items to be used under cryogenic conditions, temp below -45°C and those required to be fire-safe, special designs and tests would be applicable. Pre-qualification criteria need to be specified before execution of job.

3.4 Impact Tests
Welded Pipes and Fittings used below Temp. -29°C (LTCS material) shall be impact tested as per requirement of ASME B31.1.

3.5 Hydrogen & other demanding services
Vendor quality plan shall include the special quality checks and inspection requirements for these services. For hydrogen service CS material shall be normalizing and AS Materials shall be normalized & tempered.

“The SPECIAL REQUIREMENTS FOR HYDROGEN SERVICE”
(SPEC NO. API-941 “shall be followed for all Hydrogen and Hydrogen bearing hydrocarbon services.)

3.6 Inspection & Testing:
- All items and their parts shall be subjected to all mandatory as well as supplementary (wherever specified) tests and checks called for in the respective codes/standards/data sheets.
- The examining personnel shall have the requisite qualification and experience.
- Client and its authorized representative reserve the right to vet and suggest changes in vendor's procedures.
- Vendor's works and facilities shall be accessible to the Owner/PMC or their Representative at all reasonable times.
- Test reports for all mandatory as well as supplementary tests wherever specified shall be furnished.

4.0 POSITIVE MATERIAL IDENTIFICATION (PMI)
- All alloy steel, and higher alloyed piping material shall be subjected to PMI inspection.
- Extent and procedure of PMI shall be developed by as LSTK contractor based on Process Licensor’s requirement & Guide lines for shop works as well as for site inspection.
• Similar specification shall be developed by LSTK contractor for site inspection.

5.0 MARKING
  • All items shall be marked (stamped/etched) in accordance with the applicable code/standard/specification. In addition, the item code, if available, shall also be marked.
  • For ease of identification, the color of painted strip (wherever required) shall be as per the applicable standard.
  • Paint or ink for marking shall not contain any harmful metal or metal salts which can cause corrosive attack either ordinarily or in service.
  • Special items/smaller items shall have attached corrosion resistant tag providing salient features.

5.1 Dispatch
  • All items shall be dry, clean and free from moisture, dirt and loose foreign material of all kinds.
  • All items shall be protected from rust, corrosion, and mechanical damage during transportation, shipment and storage.
  • Rust preventive on machined surfaces to be welded shall not be harmful to welding and shall be easily removable with a petroleum solvent.
  • Ends shall be suitably protected, and the protectors shall be securely and tightly attached.
  • Each variety and size of item shall be supplied in separate packaging marked with the purchase order no., item code (if available) and the salient specifications.
  • Carbon steel, LTCS and low alloy steel valves shall be painted with one coat of inorganic zinc silicate primer after surface preparation.
## CLEARANCES

Minimum clearances for piping, equipment, structures, platforms, and supports shall be in accordance with the following table:

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roads</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Headroom for primary access roads wherever heavy duty crane movement is required.</td>
<td>9m</td>
</tr>
<tr>
<td></td>
<td>Headroom for primary access roads</td>
<td>7.5m</td>
</tr>
<tr>
<td></td>
<td>Width of primary access roads excluding shoulders</td>
<td>6m</td>
</tr>
<tr>
<td></td>
<td>Headroom for secondary roads</td>
<td>5 m</td>
</tr>
<tr>
<td></td>
<td>Width of secondary roads excluding shoulders</td>
<td>3m</td>
</tr>
<tr>
<td></td>
<td>Clearance from edge of road shoulders to platforms, equipment, and pipe associated with equipment, or similar features.</td>
<td>1.5m**</td>
</tr>
<tr>
<td><strong>Maintenance Aisles at Grade</strong></td>
<td>Horizontal clearances for equipment maintenance by hydraulic crane (12t capacity)</td>
<td>3m</td>
</tr>
<tr>
<td></td>
<td>Vertical clearance for equipment maintenance by hydraulic crane (12t capacity)</td>
<td>3.6m</td>
</tr>
<tr>
<td></td>
<td>Horizontal clearance for fork lift and similar equipment (2500 kgs capacity)</td>
<td>2.4m</td>
</tr>
<tr>
<td></td>
<td>Vertical clearance for fork lift and similar equipment (2500 kgs capacity)</td>
<td>2.4m</td>
</tr>
<tr>
<td></td>
<td>Horizontal clearances for equipment maintenance by portable manual equipment (A-frames, hand trucks, dollies or similar equipment)</td>
<td>1m</td>
</tr>
<tr>
<td></td>
<td>Vertical clearances for equipment maintenance by portable manual equipment (A-frames, hand trucks, dollies or similar equipment)</td>
<td>2.4m</td>
</tr>
<tr>
<td><strong>Walkways</strong></td>
<td>Horizontal clearance (not necessarily in a straight line)</td>
<td>750mm</td>
</tr>
<tr>
<td></td>
<td>Headroom (except for hand wheels)</td>
<td>2.2m</td>
</tr>
<tr>
<td><strong>Platforms</strong></td>
<td>Minimum width</td>
<td>750mm</td>
</tr>
<tr>
<td></td>
<td>Headroom from stairwell treads.</td>
<td>2.2m</td>
</tr>
<tr>
<td></td>
<td>Minimum clearance around any obstruction on the platform.</td>
<td>500mm</td>
</tr>
<tr>
<td></td>
<td>Headroom</td>
<td>2.2m</td>
</tr>
<tr>
<td></td>
<td>Maximum vertical distance between platforms</td>
<td>6m</td>
</tr>
<tr>
<td></td>
<td>Minimum toe clearance behind a ladder.</td>
<td>210mm</td>
</tr>
<tr>
<td></td>
<td>Minimum handrail clearance.</td>
<td>100mm</td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
<td>Minimum maintenance space required between flanges of exchangers or other equipment arranged in pairs.</td>
<td>500mm</td>
</tr>
<tr>
<td></td>
<td>Minimum maintenance space required for structural members or pipe.</td>
<td>300mm</td>
</tr>
<tr>
<td></td>
<td>Clearance from edge of road shoulder (the extreme projection)</td>
<td>1.5m</td>
</tr>
<tr>
<td><strong>Fired Equipment</strong></td>
<td>Horizontal clearance from hydrocarbon equipment (shell to shell)</td>
<td>15m</td>
</tr>
<tr>
<td></td>
<td>Exception: Reactors or equipment in alloy systems shall be located for the most economical piping arrangement.</td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Valve Hand wheels</td>
<td>Clearance from edge of road to heater shell. 3m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clearance between the outside of the hand wheel and any obstruction. 25mm*</td>
<td></td>
</tr>
<tr>
<td>Pipe (aboveground)</td>
<td>Clearance between the outside diameter of the flange and the outside diameter of pipe insulation. 25mm*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clearance between the outside diameter of the pipe, flange or insulation and a structural member. 50mm*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clearance between the outside diameter of the flange and the outside diameter of bare pipe. 25mm*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimum distance from underside of pipe to grade or platform. 300mm</td>
<td></td>
</tr>
<tr>
<td>Control Valve</td>
<td>Centreline of control valve above grade or platform. 450mm</td>
<td></td>
</tr>
<tr>
<td>Arrangement</td>
<td>Minimum centreline of control valve from face of column or wall. 600mm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Where process conditions require steam or hydrocarbon vapours to be discharged to atmosphere at a safe location, the tail pipe shall terminate as below:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance above nearest operating platform. 3m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Within radius of nearest operating platform. 7.5m</td>
<td></td>
</tr>
</tbody>
</table>

** Verify conformance with local regulations.  
* With full consideration of thermal movements
**ANNEXURE-6**

**JOB SPECIFIC REQUIREMENTS**

NOTE:- THE JOB SPECIFIC REQUIREMENTS GIVEN AS UNDER SHALL BE CONSIDERED FINAL IN CASE OF ANY CONFLICT WITH THE MAIN BODY OF DESIGN BASIS.

<table>
<thead>
<tr>
<th>Sl No</th>
<th>ITEM</th>
<th>Job Requirement</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equipment spacing (ISBL)</td>
<td>As per Piping Design basis.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Minimum pipe rack width 4m/ 6m/8m/10m/12m in single bay</td>
<td>10M for Main Rack 4M/ 6M/ 8M for Sub Racks.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Spare capacity on Rack</td>
<td>Provision of 20 % for future modifications.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Cooling water lines</td>
<td>Generally on rack up to 16” Underground above 16” (In specific cases, lower sizes may also go Underground depending on layout)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Minimum height of sleeper due to maintenance requirement</td>
<td>300mm with pavement below pipe way.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Fin-fan cooler location</td>
<td>On pipe rack and/or technological structure</td>
<td>As per Equipment Layout.</td>
</tr>
<tr>
<td>7</td>
<td>Location of pumps: -In units</td>
<td>- Inside pipe rack as far as possible with concrete slab below Air cooler.  - For, smaller width (4M, 6M &amp; 8M) rack, pumps shall be outside or on one side of rack portal.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Requirements of monorail on pumps: -under pipe rack /shed - Open area</td>
<td>Required for motor rating 45KW and above for all pumps. None</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Requirement for exchanger bundle removal a) Hydro extractor b) Monorail &amp; chain pulley block</td>
<td>Hydro extractor Where Hydro extractor mobility is difficult in running plant.</td>
<td>However, required head Room for installing monorail at later stage shall also be kept in Technical Structures.</td>
</tr>
<tr>
<td>10</td>
<td>Battery limit valves operation a) At grade. b) At elevated Platform.</td>
<td>Elevated platform provided at Battery Limit.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Pipe way road crossing</td>
<td>Overhead pipe bridges</td>
<td>At B/L with access.</td>
</tr>
<tr>
<td>12</td>
<td>Electrical cable routing underground/Above ground: - ISBL - OSBL</td>
<td>Refer Electrical Design Basis.</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Any requirement of statutory approval.</td>
<td>All statutory requirements e.g. IBR/PCB/CCE and others</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Instrument cable routing ISBL &amp; OSBL</td>
<td>Refer Instrumentation Design Basis.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Safety shower I eye wash. (In case of chemical/catalyst handling system.)</td>
<td>Required.</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Requirement of elevators.</td>
<td>Yes.</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Connectivity of all platforms at higher elevations for tall columns (i.e. between columns &amp; technological structure and between columns &amp; rack).</td>
<td>Yes. Adjacent columns/technological Structures/ rack must be connected at minimum two locations.</td>
<td></td>
</tr>
</tbody>
</table>
| 18 | Compressor/blower house for ISBL as well as OSBL  
   a) location  
   b) Maintenance requirement | a) Under shed  
   b) E.O.T. |
| 19 | Instrument Air Drier Shed | None |
| 20 | Insulation material  
   a) Hot/Tracing/safety  
   b) Electrical tracing  
   c) Cold | As per process design Basis. |
| 21 | Painting system | Blast Cleaning |
| 22 | Method of surface preparation  
   a) Mechanical tools  
   b) Blast cleaning | Sand blasting! grit blasting |
| 23 | Sand blasting! grit blasting | Grit Blasting |
| 24 | Painting of SS pipes below insulation | **  
   ** Whenever painting is not specified, Aluminium / SS foil as per piping design Basis shall be used. |
| 25 | Specific color coding Requirements. |   |
| 26 | Usage of IS grade material | Limited to Cat 'D' services |
| 27 | Usage of asbestos Gasket. | NO |
| 28 | Provision for high settlement in tank farm:  
   a) Usage of dresser coupling in tank farms.  
   b) Flexibility of piping. | Flexibility of piping. |
<p>| 29 | Steam tracing type | Standard module for steam distribution and condensate collection manifolds with integral glandless piston valve &amp; trap and carbon steel tracer pipe. |
| 30 | Bulk Material | Client agreed vendor list. |
| 31 | Engineering Drawing mode | Electronic |</p>
<table>
<thead>
<tr>
<th>No.</th>
<th>Specific Software Package for Engineering Drawings</th>
</tr>
</thead>
</table>
| 32  | - AutoCAD and AP-ISO  
     - PDS/SP 3D with Isogen  
     - Auto Plant Designer with Isogen or AP-ISO  
     - PDMS with Isogen  
     - AutoCAD |
|     | 3-D Models, capable of model review and walk through. |
| 33  | Material Control System |
| 34  | Item Coding system |
| 35  | Stress analysis package |
|     | CEASER II (Latest version) |
| 36  | Access to nozzles of columns |
|     | Platforms for all nozzles |
| 37  | Staircase / Ladders for tall column/reactors |
|     | Ladders for Columns/staircases for reactors |
| 38  | Provision of breakup flanges for removal of tube bundles of heat exchangers |
|     | Wherever necessary |
| 39  | Height of pipe support pedestals |
|     | 150 mm from FGL |
| 40  | Mandatory Bulk Material Escalation |
|     | As per mandatory spares |
| 41  | Cathodic Protection of Tankage and U/G Piping |
|     | Yes |
| 42  | Cast iron valves |
|     | Cast Iron Valves not to be used |
| 43  | Pump Suction strainers |
|     | Y-type strainers |
| 44  | Two phase flow line analysis |
|     | Both static and dynamic analysis required |
| 45  | Connectivity of the technological structure |
|     | Technological structure to be interconnected |
| 46  | Usage of check valves |
|     | Wafer dual plate and swing check valves |
|     | Unless specifically required by process |
| 47  | Traps on steam lines |
|     | Compact Steam Trap Assembly (IBR) with Thermodynamic Trap |
1.0 PURPOSE

This design basis deals with the subject of Identification of Stress Critical pipelines and preparation of Critical line list. This procedure also defines the minimum requirements for performing stress analysis, design and location of spring, support and level of system analysis with the extent of documentation required for flexibility analysis.

Purpose of piping stress analysis is to ensure:

- Safety of piping and piping components
- Safety of connected equipment and supporting structure
- Piping deflections are within the limits

2.0 SCOPE

This specification covers the supply of engineering services to perform a complete piping and pipe support analysis for piping systems for Steam Generation Plant.

3.0 DEFINITIONS

3.1 Critical Lines / Critical Line List

Critical lines or Critical Line List as referred to in this procedure relates to Piping Stress Critical Lines and does not include or refer to process critical lines.

3.2 Stress Analysis Temperature

Stress Analysis Temperature refers to either “Maximum Operating Temperature” or “Steam-out temperature / hot nitrogen purging temperature” of the lines under review whichever is higher. In absence of the above values, it refers to the Design Temperature of the line under review. The Line List should be strictly followed in obtaining the above temperature values.

3.3 Design Pressure

Design Pressure refers to the “Design Pressure” of the line under review as indicated on the Line List.

3.4 Temperature for Flexibility Analysis

The temperature to be used for the flexibility analysis shall be taken as the maximum / minimum temperature which the pipe will see under any combination of different normal / abnormal operating conditions. Where piping is exposed to direct sunlight, solar radiation temperature of 70 °C is considered in establishing the maximum temperature of piping. Even, for non-critical piping exposed to direct sunlight on pipe rack or elsewhere, expansion loops, wherever essential, are provided to take care of pipe movements resulting from piping skin temperature due to solar radiation.
In general, unless there is a difference of more than 50 °C between working Temperature and the design temperature, the design temperature should be taken as Flexibility temperature. Ambient Temperature shall be considered as 21°C the assumed piping installation temperature. The displacement stress range from this installation temperature to the minimum recorded ambient temperature of 0º C being less than the same from installation temperature to the maximum operating temperature of hot piping in most cases, the later governs as per ASME B 31.1

The temperature under fire condition is normally not considered for flexibility analysis.

3.0 SELECTION

A line is selected and listed as a Critical Line provided it falls under any one of the categories defined below and is intended to include the special requirements of Piping Stress Engineer. It is hence defined as any line for which a flexibility review is required or where pipe supporting is deemed to be critical and needs review by a Stress Engineer. Line DN 50 and smaller is inherently flexible and is not normally considered critical unless built from non-metallic or non-ferrous materials. In case of more than one applicable line size, larger line size governs. Lines are classified as Level I, Level II & Level III according to the criteria listed below.

4.1 Level I [Extensive Analysis]

Piping systems or lines that meet Annexure 7A criteria are deemed to be extremely critical. These lines are categorized as Level I and require careful study to ensure that the code compliance is met and the accurate determination of nozzle and support loads have been made. The routing of these lines is very important. They must be analyzed in the early stages of the project during routing studies so that the impact on the location of less critical lines is minimized. Normally, these systems require computer analysis. The general intent of the Level I analysis criteria is to study lines size DN 80 & larger that are affected by thermal expansion and / or a dynamic response, and that can’t be evaluated by a weight-only analysis (as per the general intent of Level II analysis). Consideration has to be given to other special situations that augment the Level I general intent guidelines such as for lines that are excessively large and stiff.

4.2 Level II [Normal Analysis]

Piping systems or lines that meet Annexure 7B criteria are moderately critical lines and often do not require such rigorous study to ensure code compliance or accurate determination of nozzle and support loads. These lines are smaller in size and operate at lower temperatures (in general) than the lines to be analyzed using Level I Criteria. Normally, only manual calculations, by use of appropriate monographs are required for analysis of these systems.

4.3 Level III [Minimum Analysis]

All lines that are outside the purview of Level I or Level II criteria will be classified as level III and shall be reviewed by the Piping Engineer during the squad check of the piping drawings and or fabrication Isometric drawings. If more detailed analysis is required, the Piping Engineer may change the level of analysis during
the squad check as applicable. Normally, only visual analysis is required for these systems.

4.4 Lines Deemed To Be Support Critical
Lines subjected to two-phase flow.
Cross country pipelines.
Lines with pipe thickness Sch 160 or greater.
Lines 16" NB and above with pipe thickness less than 8 mm.
Lines 10" NB and above with corrosion allowance 3 mm and above.
Lines with high concentrated loads such as heavy valves or fittings etc.
Lines downstream of Relief Valve / letdown Control Valves / bursting (rupture) discs.
Connecting to vent or flare systems or discharging to atmosphere
Liquid Blow down Lines.
Lined pipes
Non-metallic pipes

4.5 Lines Needing Dynamic Analysis
There are instances where in the frequency of the applied load is comparable to the natural frequency of the piping system. Such systems tend to store the energy and release it according to certain scientific laws. Such a system is dynamic in nature and the study of the response of such a system is referred to as “Dynamic Analysis”. Examples of such kind of systems are Relief Valve discharge lines, water hammer and surge in pipe lines, two phase flow in pipelines, reciprocating pumps and compressor piping, submarine piping etc.

5.0 RELATED DOCUMENTATION

5.1 Critical Line List Format.
The critical line list shall be prepared from the project line list document by inserting following relevant fields such as Stress level, stress package no., stress analysis temperature, support critical nature of the line, dynamic loadings, steam out / purge temperature etc.
The list shall reflect analysis status of line that includes its input received date from design & output handover date to design and specific remark if any.

5.2 Lines Affecting the Flexibility of Critical Lines
Non-critical Lines found to affect the flexibility of critical lines which have not been included during the initial review are subsequently added to the Critical Line List.
Non-critical Lines on which advice may be sought by the Lead Piping Engineer are not normally entered into the Critical Line List but covered verbally, or by a memorandum if a record is required.

6.0 PIPE STRESS ANALYSIS AND SUPPORTING

6.1 Piping system shall be properly supported taking in to account of the following points:
Piping stress analysis shall be as per requirement of ASME B 31.1 and shall be complete to prevent overstressing of the pipe during operating conditions with
wind and seismic loadings. During sustained, occasional (wind and seismic) & thermal expansion loading on piping,

The material allowable stresses shall be as per ASME B 31.1 for ASTM materials. For DIN material specifications the allowable stress values shall be calculated as per ASME.

6.2 Analysis shall include, but not be limited to the following; thermal, dead weight, internal pressure, wind and seismic, and a combination of these based on ASME B 31.1.

6.3 Piping shall be designed in accordance with the Indian Standard criteria for earthquake resistance design for structures IS: 1893 for seismic zone-III (refer project design basis). As a minimum, two (2) orthogonal horizontal components and a vertical component of ground motion will be considered in the seismic analysis. For American standard, loading applied to piping would be in accordance with uniform building code (UBC).

The equivalent horizontal static force method shall apply in general. The contractor shall also carry out special designs and provisions as necessary for piping which is considered to be dynamically sensitive to earthquake.

Seismic analysis to be performed for lines equal to and above 12”. Seismic load case shall ALGEBRIC combination with operating cases.

Heavy rigid masses like valves shall be restrained in their vicinity to avoid large seismic movements. Guides or snubbers as the case may be used for this purpose.

Horizontal seismic coefficient (Ah) to be considered as 0.26 and Vertical (Av) to be considered as 0.173.

6.4 Wind loads shall be calculated in accordance with IS-875 code of practice for structural safety of building – Loading Standards for Indian code requirement using basic wind speed as mentioned in project design basis. For American standard, wind load in accordance to ASCE 07 shall be calculated. Reduction in velocity pressure due to apparent shielding afforded by buildings and structure or terrain shall not be permitted.

Wind loading shall only be considered for lines larger than 20” OD at elevation higher than 10m above grade. Displacements due to wind and earthquake should be limited to 50 mm.

Both the horizontal directions shall be analyzed independently in two cases
+X, -X, +Z, -Z

Wind and seismic loading will not occur simultaneously.

6.5 Analysis of all nozzles loading on vessels within the piping boundaries is covered in this specification. Nozzle analysis shall follow the guidelines of ASME Section
VIII, Division 1, and WRC 297 & 107 (latest editions). Nozzle stresses shall fall within the allowable per ASME.

6.6 Piping system shall have sufficient flexibility to avoid leakage at joints. Flanged joints imposed by external moments may be analyzed and the stresses evaluated by using the methods of equivalent pressure given in the ASME boiler and pressure code section III. Flange leakage shall be assessed as per “Pressure Equivalent Method”. In case of Failure in Pressure Equivalent Method, the Flanges shall be checked for leakage using Caesar Flange leakage Module. Flange leakage shall be assessed for all PSV flanges, Control valve flanges, High Pressure lines, and all steam lines. Also for equipment flanges where loads are high.

6.7 All forces on connections to equipment shall not exceed maximum allowable as specified by equipment vendor.

6.8 Pipe supports loads shall be based on the maximum loads determined by the piping analysis. Adjustments shall be made to the piping system and model such that the pipe supports loads are within a reasonable uniformity throughout the piping system.

6.9 Various Load cases built in Caesar II to check stress in piping system are listed below.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>WW+HP</td>
<td>HYD</td>
</tr>
<tr>
<td>2</td>
<td>W+T1+P1</td>
<td>OPE</td>
</tr>
<tr>
<td>3</td>
<td>W+T2+P1</td>
<td>OPE</td>
</tr>
<tr>
<td>4</td>
<td>W+T1+P1+U1</td>
<td>OPE</td>
</tr>
<tr>
<td>5</td>
<td>W+T1+P1+U2</td>
<td>OPE</td>
</tr>
<tr>
<td>6</td>
<td>W+T1+P1+U3</td>
<td>OPE</td>
</tr>
<tr>
<td>7</td>
<td>W+T1+P1-U1</td>
<td>OPE</td>
</tr>
<tr>
<td>8</td>
<td>W+T1+P1-U2</td>
<td>OPE</td>
</tr>
<tr>
<td>9</td>
<td>W+T1+P1-U3</td>
<td>OPE</td>
</tr>
<tr>
<td>10</td>
<td>W+T1+P1+WIN1</td>
<td>OPE</td>
</tr>
<tr>
<td>11</td>
<td>W+T1+P1+WIN2</td>
<td>OPE</td>
</tr>
<tr>
<td>12</td>
<td>W+P1</td>
<td>SUS</td>
</tr>
<tr>
<td>13</td>
<td>W+P2</td>
<td>SUS</td>
</tr>
<tr>
<td>14</td>
<td>L2-L12</td>
<td>EXP</td>
</tr>
<tr>
<td>15</td>
<td>L3-L12</td>
<td>EXP</td>
</tr>
<tr>
<td>16</td>
<td>L4-L2</td>
<td>OCC</td>
</tr>
<tr>
<td>17</td>
<td>L5-L2</td>
<td>OCC</td>
</tr>
<tr>
<td>18</td>
<td>L6-L2</td>
<td>OCC</td>
</tr>
<tr>
<td>19</td>
<td>L7-L2</td>
<td>OCC</td>
</tr>
<tr>
<td>20</td>
<td>L8-L2</td>
<td>OCC</td>
</tr>
<tr>
<td>21</td>
<td>L9-L2</td>
<td>OCC</td>
</tr>
<tr>
<td>22</td>
<td>L10-L2</td>
<td>OCC</td>
</tr>
<tr>
<td>23</td>
<td>L11-L2</td>
<td>OCC</td>
</tr>
<tr>
<td>24</td>
<td>L12+L16</td>
<td>OCC</td>
</tr>
</tbody>
</table>
P1- Maximum Operating Pressure  W- Dead Weight
T1- Maximum Operating Temperature  WW- Water Weight
P2- Design Pressure  WIN- Wind Load
T2- Design Temperature  U- Uniform Load
HP- Hydro test Pressure  L2- Load case
SUS, EXP, OCC, HYD, OPE- Various load types, viz., sustained, occasional, hydro test, operating etc.

7.0 CODES AND STANDARDS
The following codes and standards shall apply in the design and analysis of the piping systems covered under this specification:
Allowable Stress ASME B 31.1
Piping ASME B 31.1
Nozzle Loadings as per WRC297/107(Welding Research Council) / respective code & Standard/ Vendor Allowable

Wind Analysis ASCE 7 – 98

8.0 SOFTWARE USED
The package used shall be latest version of CEASER-II.

9.0 DOCUMENT REQUIREMENT
9.1 A written report shall be submitted on the piping and equipment analysis. The report shall include all pertinent information that shall include but not be limited to the following.
Location and type of pipe supports with loads and movements.
Location of expansion joints and movements.
Vertical and horizontal loads including moments at all support points.
Vertical and horizontal loads including moments on all equipment and Vessel connections.
Caesar II analysis report, which shall include as a minimum, restraint forces, movements and stresses for all load cases. For flange connection, loaded with high bending moments and/or tensile forces in piping or at equipment connections, Caesar II flange leakage report will be provided. For piping analyzed, if subjected to hydro test, hydro test load case will be made in Caesar II to check for loading under hydro test & the requirement of any additional temporary supports for hydro test.
Detailed nodal model used for the stress analysis
All assumptions and limitations applied to the analysis
9.2 All dimensions and analysis shall be performed using metric and SI units.

9.3 The final report / stress package folder shall be submitted as follows:

1. Front sheet with Approval status
2. Isometrics with following information
   - Node numbers
   - Type of supports selected by stress engineer
   - Springs / Bellows data required for procurement like spring rate, loads, tide/untied information and SM (special material) identification.
   - Maximum Expansion and sustain stress values with node number
   - Nozzle/ Anchors initial movements and piping imposed forces and moments on the same
   - Support loads (anchors, guides or rest) only they are above limit (The limit is defined in the beginning of the project in consultation with civil)
   - Design and maximum operating conditions
   - Coordinate axis system considered for inputs
   - Dimensional details for piping designer to locate supports in piping model/layout.
3. Checklist as per Work instructions.
4. Following outputs
   - Load Cases
   - Restraint summary
   - Spring hanger report, if any
5. Stress critical line list extract for the lines analyzed
6. Piping material specifications
7. Equipment drawings with allowable loads, if available
8. PID
**ANNEXURE-7A**

**CRITERIA FOR IDENTIFYING EXTREMELY CRITICAL LINES (LEVEL I)**

<table>
<thead>
<tr>
<th>Temperature T, Degree C</th>
<th>Pipe Diameter DN (mm)</th>
<th>Piping Material</th>
<th>Service and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>All</td>
<td>All</td>
<td>Piping which will undergo hydraulic shock, auto-ignition or is in service.</td>
</tr>
<tr>
<td>All</td>
<td>DN≥80</td>
<td>All</td>
<td>(Lethal) fluid service per ASME B31.1 (No cyclic service).</td>
</tr>
<tr>
<td>All</td>
<td>DN≥80</td>
<td>All</td>
<td>Piping which is openly exposed to winds&gt; 75 mph.</td>
</tr>
<tr>
<td>T&lt;-29</td>
<td>DN≥80</td>
<td>Carbon Steel</td>
<td>All Services.</td>
</tr>
<tr>
<td>T&lt;-45</td>
<td>DN≥80</td>
<td>All</td>
<td>All Services</td>
</tr>
<tr>
<td>T≥65</td>
<td>DN≥80</td>
<td>Non-Metallic</td>
<td>All Services</td>
</tr>
<tr>
<td>T≥65</td>
<td>DN≥80</td>
<td>All</td>
<td>Lines with pressure≥900 psig.</td>
</tr>
<tr>
<td>T≥150</td>
<td>DN≥80</td>
<td>All</td>
<td>All Services</td>
</tr>
<tr>
<td>ALL</td>
<td>DN≥400</td>
<td>All</td>
<td>All Services.</td>
</tr>
<tr>
<td>T≥260</td>
<td>ALL</td>
<td>ALL</td>
<td>ALL Services.</td>
</tr>
<tr>
<td>-29≥T≥65 OR -7≥T≥50</td>
<td>DN≥80, DN≥100</td>
<td>All</td>
<td>Piping connected to nozzle load sensitive equipment, air-cooled exchangers and rotating equipment (see note 1).</td>
</tr>
<tr>
<td>ALL</td>
<td>ALL</td>
<td>All</td>
<td>Lines requiring expansion joints or flexible connectors.</td>
</tr>
<tr>
<td>DELTA T≥27 (NOTE 2)</td>
<td>DN≥80</td>
<td>All</td>
<td>Jacketed piping.</td>
</tr>
<tr>
<td>-29≥T≥65</td>
<td>DN≥100</td>
<td>All</td>
<td>Internally lined pipe (except glass).</td>
</tr>
<tr>
<td>All</td>
<td>ALL</td>
<td>All</td>
<td>Glass lined piping.</td>
</tr>
<tr>
<td>All</td>
<td>DN≥80</td>
<td>All</td>
<td>Differential Tank Settlement (Upto 3 supports from nozzle).</td>
</tr>
<tr>
<td>-40≥T≥80, -29≥T≥70</td>
<td>DN≥100, DN≥200</td>
<td>Metallic</td>
<td>Underground Piping</td>
</tr>
</tbody>
</table>

**NOTES:**

1) Load sensitive equipment include heaters, lined vessels with lining of brittle material, non-ferrous equipments, graphite heat exchangers, plate & frame heat exchangers, etc.

2) This criterion is not to be applied to auxiliary piping such as seal flush; bearing cooling, etc. delta T refers to the differential temperature between the process piping and jacket.
## ANNEXURE-7B
### CRITERIA FOR IDENTIFYING MODERATELY CRITICAL LINES (LEVEL II)

<table>
<thead>
<tr>
<th>Temperature T, Degree C</th>
<th>Pipe Diameter DN (mm)</th>
<th>Piping Material</th>
<th>Service and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>DN&lt;80</td>
<td>All</td>
<td>Lethal fluid service.</td>
</tr>
<tr>
<td>T&lt;-29</td>
<td>DN&lt;80</td>
<td>Carbon Steel</td>
<td>All Services.</td>
</tr>
<tr>
<td>T&lt;-46</td>
<td>DN&lt;80</td>
<td>All</td>
<td>All Services</td>
</tr>
<tr>
<td>95&lt;T&lt;150</td>
<td>80&lt;DN&lt;200</td>
<td>All</td>
<td>All Services</td>
</tr>
<tr>
<td>T≥65</td>
<td>DN&lt;80</td>
<td>Non-Metallic</td>
<td>All Services</td>
</tr>
<tr>
<td>T≥65</td>
<td>DN&lt;80</td>
<td>All</td>
<td>All Services</td>
</tr>
<tr>
<td>T≥65</td>
<td>DN&lt;80</td>
<td>All</td>
<td>Lines with pressure≥900 psig.</td>
</tr>
<tr>
<td>T≥150</td>
<td>DN&lt;80</td>
<td>All</td>
<td>All Services</td>
</tr>
<tr>
<td>ALL</td>
<td>200&lt;DN&lt;400</td>
<td>All</td>
<td>All Services</td>
</tr>
<tr>
<td>T≥260</td>
<td>ALL</td>
<td>ALL</td>
<td>ALL Services.</td>
</tr>
<tr>
<td>DELTA≥27(NOTE 2 of Table-1)</td>
<td>DN&lt;80</td>
<td>All</td>
<td>Jacketed piping.</td>
</tr>
<tr>
<td>All</td>
<td>ALL</td>
<td>All</td>
<td>Internally lined pipe (except glass).</td>
</tr>
<tr>
<td>All</td>
<td>DN&lt;80</td>
<td>All</td>
<td>Differential Tank Settlement (Upto 3 supports from nozzle).</td>
</tr>
<tr>
<td>All</td>
<td>ALL</td>
<td>All</td>
<td>Underground Piping</td>
</tr>
<tr>
<td>All</td>
<td>ALL</td>
<td>All</td>
<td>Piping connected to pressure relief</td>
</tr>
<tr>
<td>All</td>
<td>ALL</td>
<td>All</td>
<td>Close coupled interconnecting piping between equipment with differential movement greater than 6.0mm.</td>
</tr>
</tbody>
</table>
1.0 INTRODUCTION
The LSTK Contractor shall carry out Detailed Engineering of the plant areas specified in the scope elsewhere using 3D intelligent software.

2.0 SOFTWARE
Anyone of the following two software with Oracle database shall be used by the LSTK Contractor.

i) PDS by Intergraph USA on Windows NT with design review through dynamic walkthrough.

ii) PDMS by AVEVA UK on Windows NT with design review through dynamic walkthrough.

Isometrics shall be generated using ISOGEN Software. Latest version of all the software released as on the date of ITB shall be used by the Contractor. The LSTK Contractor shall clearly specify in his bid the software to be used with version number.

3.0 OBJECTIVE
The objective of 3D modelling is to carry out detail engineering and produce deliverables using 3D tools and conduct reviews for obtaining approvals from Owner/PMC. 3D model shall be developed and demonstrated with dynamic walk through facility to check any interference requirements of operation and maintenance for getting the approval of the Owner. LSTK contractor shall deliver to Owner/PMC a complete 3D model which shall be utilised for all future maintenance, operation, revamping and any de-bottlenecking of the plant. The 3D Design Reviews through dynamic walkthrough, through LCD projector system shall assist the Owner's operation and maintenance personnel in reviewing the project prior to construction and suggest modifications for efficient operation of the plant. Owner/PMC/ shall use it for review of design.

4.0 DEFINITIONS

4.1 EXACT GEOMETRY
The geometry of the object should be exactly as shown in vendor drawings or as per standard drawings as given in codes e.g. Pipes, Flanges. Valves, beams, etc. the geometry of the items to be modelled should be such that it serves the purpose of clash checking as well as identification of object in 3D.

4.2 NEAR EXACT GEOMETRY
SPECIAL items like bellows, traps, etc does not call for exact geometry. The provision should be made for clash checking and 3D representation of the item. A box instead of bellows, traps, etc is not acceptable.

4.3 APPROXIMATE GEOMETRY
Items like transmitters, floor stand mounted instruments where boxes instead of exact shape can be shown. The nomenclature of such items should be clearly distinguishable for easy identification.

5.0 EXTENT OF MODELLING / SCOPE OF WORK

5.1 PIPING
All design within Unit, Facility battery limit above ground and underground piping inclusive of fire fighting lines and sprinkler system, big bore and small bore,
except tubing, for all piping materials shall be modelled. Details shall include all pipes, valves, flanges, fittings, reducers, spectacle blinds, drains, temperature/pressure connections, sample points, drip legs jacketed pipes, fittings and flanges etc. Existing lines inside the battery limit (If any) along with tie-in points shall also be modelled.

5.1.2 All in line instruments like control valves, safety valves, rotameters, orifice plate etc. with near exact geometry.

5.1.3 All piping special items like expansion bellows, slide valves, special valves with purge points, steam traps, strainers etc. with near exact geometry.

5.1.4 Complete vessel trims with level gauges, level switches, level transmitters, equipment, instrument, vent/draains utility connections, pressure gauges etc. with exact geometry.

5.1.5 Steam supply and condensate recovery stations up to the first valves in tracer lines

5.1.6 All pipe supports to be Physical modelled for all sizes with secondary steel sleeper way as follows.
   a) All spring hangers, roller supports to be modelled with all details.
   b) Pipe supports along with concrete pedestals ,Type of support
   c) Details of the spring hanger's i.e. operating load, travel, spring constant should be keyed in as user-defined attributes.
   d) Details of expansion bellows i.e. type, axial/lateral deflections, stiffness etc to be keyed in as user defined attributes.
   e) Structural steel members used for the pipe supports to be modelled in complete details.

5.1.7 All equipment to be modelled with exact geometry including but not limited to: manholes with davits, pipe davits on top platforms, nozzles, stiffener rings, bellows, break flanges, platforms, ladders, handrails, lifting lugs, etc. for all the equipment in the plant like vessels, columns, reactor, receivers, pumps with motors, compressors with details of volume bottles, cylinders etc., blowers, centrifugal compressors, furnaces with soot blowers, fired heaters, burners and peep holes, air coolers with motors and fans, filters, blow down drums, all equipment within packages and heat exchangers etc.
   a) Maintenance areas around equipment, davit swing areas, swing elbows sweep areas, tube bundle removal areas for heat exchangers, rotor removal areas, and drop out areas to be modelled as soft envelopes and should be used for clash detections.
   b) Equipment supports: skirts, support legs/lugs, saddles to be modelled along with the Equipment.
   c) Insulation type (hot, cold, tracing, jacketed, etc). Insulation thickness, operating/design. Pressure /temperature, hydro test medium/pressure to be given.
   d) Equipment 3D model shall include all attachments like platforms, nozzles, ladders, pipe supports, etc.

5.1.8 Skid mounted Equipment / Package units (if applicable) shall be modelled as a Block and Piping connections at Skid/Package unit battery limit to be precisely modelled depicting complete connectivity.
   a) Skid to be tagged as main equipment.
   b) All sub-equipment of all skids to have skid tag as a prefix.
   c) All sub-equipment to be modelled with exact geometry.
   d) Complete internal Piping of the skid with all inline and online instruments to be modelled as per the details in 5.1.1 to 5.1.7
e) All pipe supports with the skids are to be modelled as per para 5.1.7

5.1.9 Tagging of all line nos., Instrument nos., special items, equipment nos. shall be as marked in the P&ID’s.

5.1.10 Complete underground piping man hole vent piping to atmosphere, catch pits, cable trays etc. to be modelled. Envelopes to be modelled on top of manholes and catch pits and shall be used for interference detection.

5.1.11 Material handling equipment e.g. Catalyst loading chutes, drumsetc. to be modelled in near exact geometry.

5.1.12 Hard stands, fabrication space for tall columns, erection access for tall structures considering crane boom and movement, crane access. Unit approaches from main roads. main roads outside the units shall also be modelled.

5.1.13 Line information required in 3-D model.
The following attributes must be keyed in while modelling:

a) Line operating/design, temperature/pressure in deg. C and kg/cm2g respectively

b) Liquid state i.e. vapour, liquid, 2-phase.

c) Insulation thickness and type i.e. IH/IC/IJ/IC etc.

d) Hydro test pressure in kg/cm2g and medium.

e) Line number label should be as per the P&ID with the following attributes: Line size + unit no + line sequence no + sub-line no + piping material specification + insulation type. User Defined Attributes (UDA’s) to be generated for keying in this information in PDMS.

5.1.14 Incorporation of site changes during fabrication and erection with 3D Model in order to deliver a complete as built model to Owner.

5.1.15 General Arrangement Drawing Extraction

a) Piping General Arrangement Drawings are to be extracted from the 3D model on AO size with a scale of 1 :33 / 1 :50 for rack Vital installations and battery limits shall be marked with coordinates.

b) All locating dimensions like spacing for equipment, structural columns, pipe-to-pipe etc. shall be marked on the GAD’s. Equipment tag numbers, line numbers, instrument and speciality item tag numbers shall be marked on the GAD’s. Electrical instrument ducts shall be marked and labelled. Access ways, maintenance corridors, dropout areas, bundle removal areas catalyst-handling areas shall be marked on the GAD’s.

5.1.16 ISOMETRIC EXTRACTION

Isometrics shall be extracted from 3D model using ISOGEN Software along with Bill of Material and logical pipe supports.

5.1.17 Interference Detection shall take care of Hard-Hard clashes and Hard-Soft clashes for all the disciplines.

5.2 STRUCTURAL

The scope of modelling for structural shall include but not limited to the following:

i) Main steel/secondary steel equipment support beams, bracing, columns with footings, stiffener plates, platforms, ladders, pipe racks, stair cases, walkways, supporting structure for all coolers with operating platforms, handrails and staircase, monorails, EOT support, including fire proofing shall be modelled in exact geometry. Existing structures inside the working battery limit to be modelled.

ii) Equipment and structure foundations, technological buildings, equipment supporting structure, flue gas stack and any other concrete structure to be modelled in exact geometry with exact locations of all insert plates.
iii) Foundation and structure for platforms, gratings, handrails etc. for packaged item and items are also included.

5.3 INSTRUMENTATION
i) Instrument ducts, cable trays greater than or equal to 300 mm width, Instrument Junction boxes to be modelled in exact geometry.
ii) Transmitters and other floor stand mounted instruments on grade/platform to be modelled in approximate geometry with tag nos. as per P&ID's.

5.4 ELECTRICAL
i) Electrical cable trays greater than or equal to 300 mm width. Electrical cable trenches all sizes, junction boxes to be modelled in exact geometry.
ii) Electrical stop/start switches for motors, to be modelled in approximate geometry.
iii) Lighting details, earth pits.
iv) Fire alarm system, e.g. fire detection point, hooters, etc.

6.0 MODEL SPLIT
6.1 Separate models to be generated for each discipline.

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Model Identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping above ground</td>
<td>P</td>
</tr>
<tr>
<td>Piping underground</td>
<td>U</td>
</tr>
<tr>
<td>Equipment</td>
<td>E</td>
</tr>
<tr>
<td>HVAC</td>
<td>H</td>
</tr>
<tr>
<td>Structural</td>
<td>S</td>
</tr>
<tr>
<td>Architectural</td>
<td>A</td>
</tr>
<tr>
<td>Electrical</td>
<td>L</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>I</td>
</tr>
</tbody>
</table>

6.2 Within each discipline models are to be generated based on the area division in piping key plan. The naming conventions for model in the PDS and Database in PDMS shall be as follows.

\[
\begin{array}{cccc}
X & X & = & XX \\
\text{Model Identifier as Levels} & \text{Under score} & \text{Area number} & \text{form Key Plan} \\
\text{given below} & & & \\
\end{array}
\]

- A – Grade
- B – First Level above grade
- C – Second Level above grade
- X – All levels in one model
- U – Under ground

- Above ground and underground piping shall always be in different models.

6.3 Database Hierarchy in PDMS

6.3.1 Piping
a) PIPE

<table>
<thead>
<tr>
<th>Line no. Label Specified in 5.1.15)</th>
<th>--</th>
<th>PX</th>
<th>--</th>
<th>XX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under score Model no. Under score Area no. From Piping Key Plan.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
b) Branch
  PIPE NAME / B1, B2

c) TAX NOS. For all Inline Instruments, Special Items as component Name in PDMS. Same tag numbering philosophy to be followed in PDS.

XXX = XXX XXXX X
UNIT No. DASH INST. INST. No. / Only if same
Type i.e. PSV, FV, special item no. no. is getting
PV repeated.

- Comments to be written in components S Text attribute.

6.3.2 Other Disciplines
Basis shall be similar to that given for piping. LSTK Contractor shall develop the Hierarchy and submit it for Owner/PMC approval prior to start of modelling

7.0 DELIVERABLES

7.1 Complete 3D model along with as built GAD's, Isometrics, and MTO reports, all extracted from the model, nozzle orientations for Piping and 3D models for all disciplines as specified in 7.1 to 7.6 with any other document generated from 3D model and naming conventions as per 7.0 to 7.3 with "As built" updates along with complete reference databases, component catalogues for all the size range in the approved specifications shall be furnished by the LSTK Contractor in electronic form.

In addition, contractor shall submit the 3D model in electronic form after completion of final review of 3D model duly updated as per comments/observations and agreed of MOMs of review sessions.

7.2 Review Models shall be installed at site having latest version of design review software and all other pre requisite software and any other software required for smooth running) and minimum configuration as stated in by the Contractor sufficiently at start of Mechanical work and & plotter at site shall be decided in consultation with Owner.

PDS and Isogen will not be installed at site. Only review data will be available on review station.

In addition LSTK Contractor to Minimum Install.
  ► One number of A3/A4 duplex laser printer
  ► One number of A0 inkjet plotter

7.3 Reference Data Bases

7.3.1 P.D.S.
The complete reference Data base developed for the FACILITIES by the LSTK Contractor on PDS and delivered shall include but not limited to the following:

7.3.1.1 Piping
1. Piping material class
2. Piping Commodity data files.
3. Short or Long material description library.
4. Specialty material description library.
5. Standard note library.
7. Piping assembly library.
8. Graphic commodity library.
10. Formats files for MTO
11. Isometric set-up (option) files.
13. Write-up of all project specific code lists, which have been, added to the standard code lists.

7.3.1.2 Other disciplines
Complete reference database with all the libraries. LSTK Contractor shall prepare a comprehensive list of these files separately for each discipline and submit it for PMC review prior to start of 3D modelling.

7.3.2 PDMS
The complete material specifications and component catalogues developed by the LSTK Contractor on PDMS and delivered shall include but not limited to the following.

7.3.2.1 Piping
1. Piping material specifications.
2. Insulation specifications
3. Bolt specification
4. Nozzle specifications
5. Complete Piping component catalogues with write-up on naming conventions used for CATALOGUE references, component references for Property Database. Bolt References for single and multiples.
6. Detail texts along with the symbol keys & R Texts
7. Material texts with X Texts
8. Any symbol key library developed for special items where Isometric Symbols by CAD Centre were not available.
9. Property database with nominal bore and outside diameter developed for the project.

7.3.2.2 Other Disciplines
Complete reference database with all the libraries. LSTK Contractor shall prepare a comprehensive list of these files separately for each discipline and submit it for PMC review prior to start of 3D modelling.

7.4 During the period of construction the above workstations and software at site shall be manned and maintained by LSTK Contractor personnel up to the completion of the Project.

7.5 Costs for all the hardware, software, networking, model transfers, ISDN link etc shall be borne by the LSTK Contractor.

7.6 Review by PMC/Owner/Licensor.
LSTK Contractor shall be responsible for arranging 3D review sessions at his design center with Dynamic walkthrough with overhead projector system, for Owner/ PMC/ Licensor comprehensive review of the 3D Models. Simultaneously a Technical Audit of the Reference Database, Component Libraries and Project Database shall be carried out by PMC. LSTK Contractor shall make one workstation available for the entire duration of the Technical Audit to the audit team along with Contractors support team, without any extra cost to PMC/Owner.
Incorporation of the comments of the Technical Audit shall be done by the LSTK Contractor without any cost or time impact. LSTK contractor shall send fortnightly updates of the model using latest version of 3D modeling software (compatible to the one at OWNER /PMC Office) for the review status monitoring of the models. LSTK Contractor shall propose the dates and duration at least 4 weeks in advance for these 3D reviews by Owner/PMC.

7.7 Review Stage

There shall be minimum 3 review stages to be done as follows. 4th and 5th further reviews shall be required after all comments are incorporated by the LSTK Contractor.

1. Equipment layout review from erection, construction, operation and maintenance point of view & Conceptual review of critical lines (thermal & process critical) (30%).
2. Before issue of model for engineering (60%).
3. Before issue of model for construction (before isometric generation commences) (90%).

3-D modeling review for sprinkler system for pumps where monorail is provided. Shall be done with sprinkler system in place.

3-D modeling review for material requirement has to be fine tuned as per 3D modeling and report of such material requirement shall be forwarded to PMC/OWNER for their information on regular interval.

Any operational requirements such as platforms, approaches for equipment & technological structure if required during the 3D model review as above, the same shall be provided by the LSTK contractor without any time delay and cost implications.

8.0 PROVEN TRACK RECORD

The LSTK Contractor or his Engineering sub-Contractor must have carried out extensive 3D modeling and data base management for a project of similar nature with the following as a minimum.

LSTK Contractor should demonstrate their capability through walk through of one such 3D model developed by them.

Owner/PMC reserve the right to verify the above at the premises (as applicable) including experience of personnel deployed on the project Owner/PMC decision shall be final and binding on the LSTK Contractor in this regard.
Section-VI-5.3.2

DESIGN PHILOSOPHY – STATIC EQUIPMENT

PLANT : STEAM GENERATION PLANT

PROJECT : INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA
CONTENTS

<table>
<thead>
<tr>
<th>SL.NO.</th>
<th>DESCRIPTION</th>
<th>SHEET NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>General</td>
<td>3</td>
</tr>
<tr>
<td>2.0</td>
<td>Equipment Design Basis</td>
<td>16</td>
</tr>
<tr>
<td>3.0</td>
<td>Technical Requirements</td>
<td>22</td>
</tr>
<tr>
<td>4.0</td>
<td>Spare Parts</td>
<td>42</td>
</tr>
<tr>
<td>5.0</td>
<td>Documentation Schedule</td>
<td>42</td>
</tr>
<tr>
<td>6.0</td>
<td>Vendor List</td>
<td>42</td>
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</table>

LIST OF ATTACHMENTS

<table>
<thead>
<tr>
<th>ATTACHMENT NUMBER</th>
<th>DESCRIPTION</th>
<th>NUMBER OF SHEETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annexure - 1</td>
<td>Guidelines For Dynamic Wind Analysis</td>
<td>2</td>
</tr>
<tr>
<td>Annexure - 2</td>
<td>Inspection (Guidelines)</td>
<td>3</td>
</tr>
</tbody>
</table>
1.0 GENERAL

1.1 SCOPE

1.1.1 This document defines the design philosophy to be applied to the design of various types of static equipment i.e. Pressure Vessels, Heat Exchangers, Power and Waste heat Boilers, Storage Tanks, and Vessel Internals e.t.c for Steam Generation Plant for the M/s TALCHER FERTILIZERS LIMITED.

1.1.2 The complete design, material of construction/fabrication (shop/site as applicable), inspection, testing, painting, supply, transportation and erection of equipment etc. at project site shall conform to the specifications, drawings and internationally accepted codes / standards duly accepted by the Owner. In addition, all statutory rules & regulations shall also be complied with.

1.2 CODES AND STANDARDS

1.2.1 The equipment shall be designed & constructed as per the latest edition of the following codes and standards:

<table>
<thead>
<tr>
<th>Code**</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASME Section VIII Div 1 &amp; 2</td>
<td>Rules for construction of Unfired Pressure Vessels</td>
</tr>
<tr>
<td>TEMA ‘R’ / API 660</td>
<td>Standards of Tubular Exchangers Manufacturer’s Association / For Shell &amp; Tube Heat Exchanger</td>
</tr>
<tr>
<td>HEI</td>
<td>Heat Exchanger Institute standards for steam surface condensers and steam jet ejectors</td>
</tr>
<tr>
<td>API 661</td>
<td>Air Cooled Heat Exchangers</td>
</tr>
<tr>
<td>API 662</td>
<td>Plate type Heat Exchangers</td>
</tr>
<tr>
<td>ASME Section 1 &amp; IBR</td>
<td>Rules for Construction of Power Boiler &amp; Indian Boiler regulations</td>
</tr>
<tr>
<td>API 620</td>
<td>Design &amp; Construction of Large, Welded, Low-pressure Storage Tank</td>
</tr>
<tr>
<td>API 625</td>
<td>Tank Systems For Refrigerated Liquefied Gas Storage</td>
</tr>
<tr>
<td>API 650</td>
<td>Welded Steel Tanks for Oil Storage</td>
</tr>
<tr>
<td>API RP 2000</td>
<td>Venting Atmospheric and Low pressure storage Tanks</td>
</tr>
<tr>
<td>Standard</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>API 2550</td>
<td>Method for measurement and calibration of upright cylindrical Tanks</td>
</tr>
<tr>
<td>API 941</td>
<td>Steels for Hydrogen Service at Elevated Temperature &amp; Pressure</td>
</tr>
<tr>
<td>API 605</td>
<td>Metallic gaskets for raised face pipe flanges &amp; flanged Connections(Double jacketed corrugated &amp; Spiral wound)</td>
</tr>
<tr>
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* Except for heat exchangers, while for heat exchangers the expansion bellows shall be designed as per TEMA standard.
NOTES:

1. LSTK Contractor may select DIN, BS or any other well known international materials as substituted materials to ASTM/ASME ones, if they are equivalent or superior to ASTM / ASME ones. The chemical & mechanical properties of such equivalent or superior offered materials preferably comparison w.r.t. ASTM materials shall be furnished along the bid. LSTK Contractor shall also submit the references of past supplies of similar type of equipment w.r.t. the proposed materials offered by them in their bid.

2. OEMs guidelines / standards may be adopted complying minimum requirements of this design philosophy of static equipment. Details of such selected guidelines/standards along with the list shall be furnished in the bid.

3. Specifications of all critical equipments including those specified by the OEM shall be furnished in the technical bid.

4. The work falling under the purview of Indian Boiler Regulations (IBR) shall completely meet or exceed all the requirements of the latest edition of IBR. Any other standard acceptable to IBR can also be considered, provided the requirements of that standard are equivalent or exceed IBR requirement

**Any conflicts between documents, including regulations and codes, shall be brought to the Purchaser’s attention for resolution.

1.3 REGULATIONS

All items of equipment shall comply with the latest Indian Boiler Regulations and stipulations of Inspectorate of Factories, Chief Electrical Inspectorate and other statutory bodies as per the requirement. Wherever required, the LSTK Contractor has to obtain the necessary approvals from statutory authorities and other concerned agencies. All cost, on these accounts shall be borne by the LSTK Contractor. Static and Mobile Pressure Vessel (SMPV) rules as applicable shall also be complied with.

PUBLICATIONS:

WRC Bulletin # 107  Local Stresses in Spherical & Cylindrical Shells due to External
Loadings.

WRC Bulletin # 297 Local Stresses in Cylindrical Shells due to External Loadings on Nozzles

1.4 SITE CONDITIONS

1.4.1 Climatic and other site conditions as defined elsewhere (as per design philosophy- Process/Civil).

1.5 OPERATING DUTY

1.5.1 Service shall be twenty-four (24) hours per day, seven (7) days per week, and fifty-two (52) weeks per year.

1.6 DESIGN DOCUMENTATION

1.6.1 Detailed design calculations considering different loadings shall be made as per code/standards and the additional requirements as mentioned below:

1.6.2 Design of equipment inside the Steam generation plant complex shall be in accordance with the OEM's data sheets and specifications.

1.6.3 LSTK Contractor shall consider the interfaces with other engineering disciplines w.r.t.

- Piping Layout/Location Drawings
- Civil / Structural Drawings
- P & ID’s
- Materials
- 3D PDS Model for Piping and Equipment Layout
- Hazardous Area Classification

1.6.4 Design philosophy of other disciplines shall be observed and shall be relevant to the extent applicable.

- Civil/Structural Design Criteria
- Piping Design Criteria
- Process Design Criteria
- Electrical and Instrumentation Design Criteria

1.7 SAFETY

1.7.1 Safety standards and features which are inherent in the specific mechanical equipment design codes, standards and regulations are applicable to this criterion. Job Hazard and Operability [HAZOP] as per OHSAS-18001 & Factory Act shall be done during design stage the equipment.

1.7.2 Safety features to be incorporated into the design include, but are not limited to, the following features for equipment:

- Ladder cages
- Safety chain across platform access
- Step-off platforms with Hand Railing where necessary
- Platform grating with adequate thickness
- Toe plates

1.8 EQUIPMENT FABRICATION

1.8.1 Equipment design shall be based on maximizing shop fabrication and assembly where deemed practical. Fabrication in open yard shall be avoided.

1.8.2 The LSTK Contractor shall comply in all respects with the provision of the applicable codes / standards and specification during fabrication.

1.8.3 Impact test, when required as per code and specifications, shall be carried out on parent metal, weld and HAZ.

1.8.4 Production Control coupons, when required as per code and specifications, shall be subjected to all tests like impact, inter granular corrosion test etc., in addition to mechanical test as required. In case of heat treated equipment test coupons shall be given similar heat treatment as for the equipment.
1.8.5 Due provisions must be kept for venting out entrapped gases during welding of pads, flanges and liner plates etc.

1.8.6 In case of equipment involving site assembly/fabrication the entire site job including loading & unloading at site, fabrication, radiography, heat treatment, Inspection & testing etc. shall be included in the scope of supply.

1.8.7 All nozzle connections up to DN 10” size shall be made of seamless pipes. For sizes above DN 10” nozzles connection may be rolled from plates with full radiography of welds.

1.8.8 No welding, hammering or deforming is permitted on the pressure retaining parts after post weld heat treatment except as permitted by the codes or standards and when approved by the Owner/PMC.

1.8.9 Flange facing and thread connection shall be protected against oxidation during Heat Treatment.

1.8.10 All welding shall be done by metal arc welding. For welding on thinner gauge sheets TIG welding is preferred.

1.8.11 Gas or Carbon arc welding shall not be used.

1.8.12 Welding electrodes of composition similar to Internals material shall be used except austenitic electrodes of higher chromium and nickel content such as AWS A5.4, ASME SFA 5.4 class E309 and E310 may be used for 12-Cr stainless steel. For dissimilar material welding, electrode composition shall be similar to nobler material being welded. Following electrodes shall be used unless specified otherwise:

- E 7018 for all CS materials
- E 308 for all SS 304 to SS 304
- E 308L for all SS 304L to SS 304L
- E 309 MoL for SS 410S to SS 410S, SS to CS, SS 410S to SS 304, 304L, 316, 316L
1.8.13 Welding wherever specified, is to be done by qualified and approved welders using the suitable fillers and fluxes recommended for the materials in the fabrication drawings. For welding the stud on tray decks and support beams, use of stud welding gun with suitable flux is acceptable. In manually welding of studs, care should be taken to minimize the weld spatter and the outside diameter of the weld so that it should not foul with tray deck or washer. For stud welding, proper welding procedure shall be established. Torque required for welding failure shall be higher than the torque required for failure of the stud.

1.8.14 A proposed Welding Procedure Specification (WPS) shall be submitted to Third Party inspection agency for approval. On approval, a Procedure Qualification Test (PQT) shall be conducted which shall be witnessed by Third Party inspection agency. On acceptance of all tests as per ASME Section IX, a final WPS along with Procedure Qualification Record (PQR) shall be submitted. Production welding shall start only after approval of final WPS/PQR and qualification of welders as per ASME Section IX.

1.8.15 Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible.

1.8.16 MISCELLANEOUS

1.8.16.1 All parts fabricated shall be smooth, true, clean and free from burrs, grease and dents. Openings for passage of workman must have exposed edges rounded.

1.8.16.2 All support rings, bolting bars, beams support brackets and other components which are integral and therefore welded to the column shell inside, shall be supplied and installed by column fabricator.

1.8.16.3 Total draw-off trays shall be designed for zero leakage construction and may be seal welded (if required) at site to attain zero leakage.
1.8.16.4 Seal welds shall have a throat thickness at least equal to the specified Corrosion allowance.

1.8.16.5 All stainless steel tray assemblies/internals and their components (e.g. Bubble caps, valves etc.) shall be pickled and Passivated. Pickling and Passivation shall be as per ASTM A380.

1.8.16.6 All parts shall be fabricated in accordance with good engineering practice and in uniformity so that all corresponding parts will be inter-changeable.

1.9 CONSTRUCTION & ERECTION

1.9.1 LSTK Contractor shall follow standard established procedures for handling storage, construction & erection. LSTK Contractor shall strictly follow Manufacturer’s/Principal’s instructions, approved drawings and procedures for construction & erection and satisfy Principal in all respects of storage, handling, construction & erection of Package. All erection work shall conform to the working/erection drawings (to be prepared by LSTK Contractor) and shall be in conformity with codes & standards as applicable. The LSTK Contractor shall supply & arrange all necessary construction & erection tools and tackles, machinery, scaffolding etc.

1.9.2 LSTK Contractor shall perform the following:

i) Before installing the equipment, the foundations shall be checked and wherever necessary, chipping shall be done by the LSTK Contractor. All grouting materials, packing plates/wedges required for the levelling and alignment of equipment, structures & pipelines etc. shall be provided.

ii) Top of the foundations shall be thoroughly cleaned to the satisfaction of Principal / LSTK Contractor before placing base plates.

iii) All equipment & structure etc. shall be checked and inspected for its proper levelling and granting (grouting) shall be done with suitable grouting material as required.

iv) After tightening the foundation bolts, the final level / alignment shall be rechecked and redone, if required.

v) Installation of all supports and hangers, including concreting or welding as necessary.

vi) To check correctness of the piping, instruments and other connecting points in the equipment and piping installed.

vii) The welding joints shall be stress relieved wherever necessary as per applicable codes, standards & specifications.
1.9.3 The following shall be arranged and supplied by LSTK Contractor for completion of job. Any other item whatsoever required shall also be included by LSTK Contractor in their scope.

i) All construction & erection materials, equipment & machinery, scaffolding, consumable, and test equipment etc.

ii) Cranes/Hydra, temporary lifting beams and spreaders etc.

iii) Procedures for site assembly, construction & erection including lifting methodology for Owner/Third party approval.

1.9.4 As a minimum contractor shall comply the requirements indicated below:

i) Fabricate, erect and align the equipment & internals as per applicable codes, standards & specifications. All internals shall be inspected before and after installation.

ii) Carry out all NDT’s required. The Personnel performing NDT’s should have a minimum qualification as “NDT LEVEL-II” in the relevant Technique, certified by American Society for Non-destructive Testing.

iii) Perform non-operating field pressure tests and leak tests on field fabricated equipment in accordance with the applicable codes, standards and specifications, ensuring disposal of test media in accordance with instruction/recommendations.

iv) Notify Owner / Third party of the test schedules for witness the tests by concerned inspector.

1.10 MATERIAL OF CONSTRUCTION

The minimum requirement of the materials shall be as per the plant equipment metallurgy covered under specific process design guidelines. However superior materials as per the recommendation of OEM’s may be selected which shall be indicated in the Bid by the LSTK Contractor.

1.10.1 All materials, whatsoever, required to complete the supplies shall be procured by LSTK Contractor and all such materials shall be covered with due identifiable material test certificate.

1.10.2 Materials used in low temperature service shall be impact tested (charpy V) if required as per design code & specification. Impact test & energy value shall be in accordance with code requirement, unless specified otherwise.
1.10.3 For coarse grained & high tensile materials in carbon steels (UTS>45 Kg/mm²) & low alloy steel, guaranteed impact strength shall be ensured at a temperature 15 °C below envisaged hydraulic test temperature as a precaution against brittle fracture during hydraulic test.

1.10.4 **HEAT TREATMENT**

Heat treatment of formed parts shall be carried out as per following:

**For Carbon Steel:**

a. Cold formed dished ends or knuckles upto 16 mm nominal thickness shall be stress relieved.
b. Cold formed dished ends or knuckles above 16 mm nominal thickness shall be normalised.
c. **For Low alloy Steel:** Cold Formed Dish ends or Knuckles shall be stress relieved.
d. Hot formed dished ends or similar parts, which have not been uniformly heated in the normalising range in the final stages of manufacture shall be normalised.
e. When the completed vessel involves post weld heat treatment, heat treatment recommended in (a) above shall not be applicable.
f. Vessels in caustic service, Amine or Sour gas service shall be stress relieved.
g. All internal and external attachments, clips, insulation studs, name plate bracket, and the like Shall be welded to the vessel before post weld heat treatment.

1.10.5 All CS materials including forging used for pressure parts shall be procured in fully Killed and normalized condition. All LAS materials including forging used for pressure parts shall be procured as permitted in ASME sec. II part A.

However CS & LAS materials above 50 mm thickness shall be Vacuum degassed except for plate ring flanges.

1.10.6 All SS plates shall be hot rolled & solution annealed and pickled as per SA 480.

1.10.7 All plates above 50 mm thickness shall be examined by UT as per ASTM-A435 at mills for both at surface & edges.
1.10.8 Cladded plates shall be supplied as per ASTM A264 material specification. All clad plate shall be UT examined at the steel works in accordance with ASTM A578 level S8.

1.10.9 The minimum thickness of weld overlay material shall be 1/8 inch (3 mm-undiluted) except clad or weld overlay tube sheets and gasket surfaces.

1.10.10 Tube sheets shall have a nominal clad or weld overlay thickness of 3/8 inch (10 mm) but not less than 5/16 inches (8 mm-undiluted) regardless of shell side or tube side face. The minimum thickness of clad or weld overlay at a pass partition groove shall be 1/8 inch (3 mm-undiluted) minimum.

1.10.11 Weld overlayed nozzle and girth flange gasket faces shall have a minimum thickness of 3/16 inch (4.8 mm) after machining.

1.10.12 All forgings except for flanges as per ANSI shall be UT tested as per ASTM A 388 for the thickness greater than 50mm and shall be procured in normalized / annealed condition. Acceptance standards shall be as per AM 203.2 of ASME Section VIII Div. 2. In case any defect is found, no repair by welding shall be allowed.

1.10.13 All forgings including nozzle flanges shall be examined for surface defects by MP/PT testing after machining as per ASTM A 275.

1.10.14 Tube sheet and Girth flanges must be made in one piece. Segmental butt-weld construction shall not be accepted.

1.10.15 Unless more restrictive prescription given by material specification the max. Carbon Content for carbon steel used for fabrication as shown by ladle analysis shall be 0.23% for plates, pipes & tubes 0.25% for forging.

1.10.16 In order to minimise the effect of temper embrittlement for material to 2¼ Cr 1 Mo specifications in the temperature range of 375-575°C, the embrittlement factors 'X' & 'J' shall be limited to:

\[
X = \frac{(10P + 5Sb + 4Sn + AS)}{100} \leq 15
\]

The elements above are expressed as ppm.
J = (Si + Mn) (P + Sn) \times 10^4 < 160

The elements above are expressed as percentages

A stimulated PWHT followed by step cooling shall be performed on a sample of material. Acceptable toughness shall be demonstrated by means of a Charpy V Impact Test.

1.10.17 Top portion of skirt (min. 500 mm height) welded to the bottom dished head shall be of same material as that of shell /head for LAS & SS materials.

1.10.18 All directly welded external/internal attachments shall be of same materials as that of equipment, unless specified otherwise.

1.10.19 Unless otherwise specified, all internal parts shall be removal type. Internal shall be designed in units as large as can be installed through the nearest upper manhole or opening. The weight of unit shall not generally exceed 40 Kg. except for support beams.

Trays, distributors, baffles and support beams shall be designed in such a way that deformation of shell due to operating pressure and thermal expansion does not occur.

Bolts and nuts for fixing internals shall be 18/8 S.S and minimum size of bolts shall be M10. All internal bolts shall be provided with locking nuts

1.10.20 External parts which are not strength welded to the shell, such as clips for insulation support rings, may be of carbon steel, provided if SS 304 stainless steel pads are furnished between shell & external parts.

1.10.21 PWHT of complete vessel shall be carried out in one go in a furnace. Local stress relieving of weld joint in piece meal shall be avoided as far as possible.

1.10.22 Steel for Hydrogen service at elevated Temperature & pressure shall be selected as per API 941 & API 934. The following special requirements shall be met with for Hydrogen/Sour gas as per NACE standard.

a) All pressure parts shall be post weld heat treated.

b) All pressure retaining welds shall be 100% radiographed. (Root run shall be Liquid
penetrant tested however, 100% radiography shall be carried out after completion of full welding of joint.)

  c) Hardness of base metals, weld and HAZ shall not exceed 22 HRC.

1.10.23 For high pressure equipments, in shell & heads, the impurity limit shall be Copper ≤ 0.20% & Nickel ≤ 0.30% for Mo & Cr- Mo low alloy steels while Copper shall be ≤ 0.20% & Vanadium ≤ 0.15% for carbon steels.

1.10.24 For equipment designed as per Power Boiler code ASME SECTION I, materials shall strictly comply with the requirements of the code. All material must be procured from well known recommended steel makers. All documents & Drawings shall be approved by IBR authorities.

1.10.25 Girth flanges must be made in one piece. Segmental butt-weld construction shall not be accepted.

1.10.26 For gaskets following shall be considered:

  a) Gaskets used for hydro test shall be same as service Gaskets specified for Operating conditions.

  b) Gaskets shall be replaced only where flanges need to be opened after hydro test. Balance places where flanges are not opened, Gasket need not to be replaced.

  b) Welded, lip seal type, double conical gaskets, RTJ and Lens gasket will not be replaced after hydro test as the same are reusable. These gaskets to be replaced, if they are found damaged during or post hydro test.

1.10.27 For equipment designed as per IBR, materials shall strictly comply with the requirement of the IBR code.

1.10.28 Hydro testing of equipment shall be as per UG-99b of ASME Section VIII Div.1. Design pressure for each nozzle shall be sum of maximum allowable working pressure and static head of corresponding nozzles.

1.10.29 All directly welded external/internal attachments shall be of same materials as that equipment, unless specified otherwise.
1.11 QUALITY ASSURANCE & CONTROL

1.11.1 The quality assurance shall be as per the approved procedures, test methods & facilities to be developed by the LSTK Contractor to ensure that the supplied equipment shall be of highest quality.

1.11.2 Quality Assurance (QA) shall mean the organizational set up, procedures as well as test methods and facilities developed by LSTK Contractor in order to assure that Equipment leaving LSTK Contractor’s shop are of the highest possible quality i.e. either equal to or better than the requirement specified.

1.11.3 Quality Control (QC), shall mean all the tests, measurement, checks and calibration which are to be carried out in LSTK Contractor’s shop in order to compare the actual characteristics of the equipment/unit/system with the specified ones, along with furnishing of the relevant documentation (certificates/records) containing the data or result of these activities.

1.11.4 LSTK Contractor shall submit a comprehensive description (manual) of QA/QC measures contemplated by him for implementation with regard to this specification. It is contractual obligation of the LSTK Contractor to develop and implement adequate QA/QC systems.

1.11.5 QA/QC system shall cover all products and services required for the equipment as per scope of work including job sub contracted by the LSTK Contractor.

2.0 EQUIPMENT DESIGN BASIS

2.1 GENERAL

2.1.1 Design conditions for all equipment shall be in accordance with the OEM data sheets/specifications. However, in any case design pressure shall not be lower than 10% over the maximum anticipated operating pressure and design temperature should be 25°C higher than the maximum anticipated operating temperature for all equipment unless otherwise specified.
2.1.2 Design pressure is normally specified at the top of vertical vessel or at the highest point of horizontal vessel. The design pressure at any lower point shall be determined by adding the maximum operating liquid head and any pressure gradient within the vessel.

2.1.3 Wind forces shall be increased by 20% to cater for the effect of piping system, platforms and ladders etc. Vertical vessels with height/diameter ratio equal to or greater than 10 shall be analyzed for vibration due to vortex shedding when critical wind speed does not exceed 30m/s. For guidelines of Dynamic Wind Analysis refer Annexeure-I.

2.1.4 Forces and moments acting on nozzles shall be considered in the equipment design. The exact forces & moments shall be indicated after piping layout which shall be considered by equipment supplier/LSTK contractor without any commercial implication to Owner.

2.1.5 All Carbon Steel (CS) and Low-Alloy Steel (LAS) pressure parts shall have 3 mm corrosion allowance unless specified otherwise. All internal CS & LAS parts shall have at least 1.5 mm Corrosion Allowance on either side. No corrosion allowance shall be considered for SS. The recommendation of OEM shall be adopted, if found more stringent.

2.1.6 Design of supports and anchor bolts considering soil and importance factors shall be performed for compressive and tensile loading. In no case shall diameter of anchor bolts be less than M24 for skirt support and M16 for other type of support.

2.1.7 Lifting lug, lifting trunion, tailing lug etc. shall be designed with shock factor 2.

2.1.8 Bolt of size M 36 and above shall be designed and spaced so as to permit tightening with a hydraulic stud-tensioner. The bolts shall have an extra threaded length at one end of approximately 1 bolt diameter, and shall be provided with threaded protection caps. Hex nuts shall have suitable holes for manual tightening. The requisite no. of hydraulic stud-tensioner device with necessary adopters/insertions based on varying sizes of studs shall be supplied by LSTK Contractor as per mechanical design of the equipment.

2.1.9 When design pressure is more than 600# class and/or shell thickness is 50 mm and above, selfreinforced forged nozzle shall be provided. Shell to SR nozzle welding shall be set-in type welding.
2.10 In case of nozzle with butt-end construction, extra length shall be provided to facilitate hydraulic testing and subsequently cutting and edge preparation to suit piping welding at site.

2.11 Orientation of longitudinal seams and position of circumferential seams shall be clearly marked in the fabrication drawing. Nozzles, support and other attachments shall be located clear of welded joints.

2.12 LSTK Contractor shall mark tangent lines, the position of the main axis and the center of gravity for orientation in a clearly identifiable and permanent way on the vessel. Centre of gravity shall be clearly marked.

2.2 INSPECTION AND TESTING

2.2.1 Equipment shall be inspected by TPIA. The Inspection and testing shall be in accordance with the relevant codes, standards, specifications, including mandatory NDT requirements indicated under Inspection and Testing clause 2.2.3 & Inspection guidelines (Annexure-2). All equipment & bought-out items shall be inspected during various stages of manufacturing starting from identification of materials to final completion as per agreed QAP which shall be prepared by LSTK Contractor and shall duly approved by Owner/ It’s authorised representative. In case of site fabricated/assembled equipment same inspection agency shall be responsible for inspection and testing at site. The guidelines for minimum inspection requirements are listed in Annexure-2 & also defined under Inspection & Testing clause of the design philosophy.

2.2.2 All testing accessories, measuring instruments including NDT testing equipment, etc. shall be arranged by LSTK Contractor.

2.2.3 The following NDT requirements are mandatory in addition to code/spec requirements:

   a) UT examination:

      i) All butt-welds in thickness greater than 50mm as supplement to radiography.
      ii) FPW of nozzle attachments of thk. above 50mm as supplement to radiography
      iii) Clad Plates and formed heads from clad plates in all thicknesses
b) **MP/PT examination**

i) All edges of plates and opening in shell of CS having thk. above 40mm and LAS/SS having thk. More than 25mm  
ii) Root and final layer of all butt welds  
iii) Fillet welds of 3.5% Ni & SS  
iv) Each layer of weld deposit in SS overlay  
v) Knuckle surfaces of dished ends, expansion bellows and pipe bends

c) **Radiography:**

i) All weld seams of formed head, if made in more than one segment shall be fully Radiographed after forming.  
ii) All the welded T- Joints shall be fully radiographed.  
iii) When spot radiography is specified all T-joints & min. 10% of total weld length excluding T-joints shall be radiographed  
v) Radiography of welds in C- 1/2 Mo & Cr- Mo - Steel preferably is carried out after heat treatment

d) Hardness test on welds of Cr-Mo, Materials after final heat treatment. The value shall not exceed to:

i) 215 HB for steel having Cr content less than 2%  
ii) 240 HB for steel having Cr content more than 2%

2.2.4. All completed equipment shall be tested hydraulically as per the requirements of Specification/codes in presence of the inspecting authority. Pneumatic test of completed Equipment shall be carried out only when specially mentioned in the specification sheets. Chloride content in water used for testing shall not exceed 30 ppm for SS equipment and 40 ppm for CS and low alloy steel equipment. Duration of test shall be 1 hour minimum. After hydro testing stainless steel vessels shall be dried thoroughly immediately after draining to prevent the possibility of evaporation & concentration of chlorides
2.2.5 All process equipments shall be supplied with Nitrogen filled. In case of equipment assembled and welded at site, it shall be filled with N₂ after testing at site. Dry Nitrogen shall be filled at a pressure of 0.5 Kg/cm² and equipment shall be fitted with a pressure gauge and valve along with nitrogen cylinder.

2.2.6 Special tools/tackles as recommended by equipment manufacturer shall be included in the scope of contractor. Hydraulic bolt tensioners where specifically recommended by Process Licenser’s specification shall be supplied with 4 bolt tightening heads.

2.2.7 Equipment under preview of statutory bodies shall be inspected during various stages of fabrication by their authorised inspecting agency. It is the responsibility of the LSTK Contractor to get the design calculations and fabrication drgs. approved by concerned statutory bodies before commencing fabrication.

2.2.8 Bidder will provide EN 10204 Type 3.2 certification for all high pressure equipment except IBR equipments.

Further, other than high pressure equipment, Bidder will provide EN 10204 Type 3.1 certification, Where, Bidder considers equipment having design pressure of equal or more than 100 kg/cm² G or thickness greater than 50 mm as high pressure equipment.

Further material from traders and stockists for static equipments is not acceptable.

2.2.9 After hydrostatic testing, the tightness of lining welds shall be tested by helium. The sensitivity of leak detection shall be as per ASME SEC V.

2.2.10 No preservative or paint will be allowed to cover any joint, mechanical or welded, before the pressure test is completed.

2.3 PAINTING

2.3.1 All external surfaces of shop fabricated equipment shall be painted in the vendor’s shop. For guidelines of painting refer TS-2001 attached with construction & erection philosophy.

2.4 PICKLING AND PASSIVATION

All SS material equipments shall be Pickled & Passivated as per following procedures:
2.4.1 PICKLING

Aqueous pickling solution shall be as follows:

Nitric acid (Tech grade)-10 to 25% plus Hydrofluoric acid-1 to 8% (to be used only for stabilized SS grades). Temperature 50 to 60°C for 10% Nitric acid and 20°C for 25% Nitric acid. When size and shape of product permit, total immersion in the pickling solution is preferred. Where immersion is impractical, pickling may be accomplished by wetting the surface by

i) Swabbing or spraying

ii) Partial filling the item with pickling solution and rotating or rocking so that the entire surfaces receive the required chemical treatment.

The maximum period for which the pickling solution shall be allowed to remain on the surface is 30 minute. During pickling removal of oxides may be hastened by brushing with a hard fiber or SS wire brush. Over pickling shall be avoided.

The pickling agent shall be washed off with plenty of water so as to leave no trace behind.

2.4.2 PASSIVATION

After pickling and water rinsing, an aqueous caustic permanganate solution containing NaOH 10 weight % and KMnO₄ 4 weight % shall be used for neutralizing pickling solution. This shall be followed by thorough water rinsing.

Water used for pickling and washing shall not have chloride contents exceeding 30 ppm.

2.5 FIRE PROOFING

2.5.1 Fire proofing, if required shall be considered as per OEM’s recommendations.

2.6 INSULATION
2.6.1 The equipment shall be insulated as defined in Piping Design philosophy.

2.7 OPERABILITY AND MAINTENANCE

2.7.1 Equipment design and layout shall provide for ease of access, operability and maintenance.

2.8 DESPATCH

2.8.1 Equipment intended for ship transportation shall be transported in the hatch of the ship. Suitable seaworthy packing/painting shall be applied to avoid any damage during transportation.

2.8.2 The complete transport, packing & forwarding of equipment shall be the responsibility of LSTK Contractor. In case of inland transportation, equipment shall be properly lashed/fixed on the wagon/trailer to avoid any damage due to shocks during transport. In case of ODC (Over Dimensional Consignment) movement, ODC sanction for movement either by rail/road shall be arranged by LSTK Contractor from appropriate authorities.

2.8.3 All spares shall be properly packed, marked & sent separately along with equipment.

2.8.4 Equipment shall be despatched with nitrogen filling. Dry nitrogen shall be filled at a pressure of 0.5 kg/cm² and equipment shall be filled with a pressure gauge and a valve along with nitrogen cylinder.

2.9 GUARANTEES

2.9.1 MECHANICAL GUARANTEE

LSTK Contractor shall guarantee the equipment & their components against faulty design with regard to their mechanical adequacy, improper material of construction & poor workmanship for the period specified in contract.

2.9.2 PERFORMANCE GUARANTEE
LSTK Contractor shall stand Guarantee of equipment as per respective technical specifications/Process Data sheets.

3.0 TECHNICAL REQUIREMENTS

PART A - DESIGN PHILOSOPHY FOR PRESSURE VESSEL

3.1 GENERAL

SCOPE

This specification covers the minimum requirements for the design, materials, fabrication, and inspection of welded pressure vessels which are defined in U-I of ASME Code Section VIII, Division 1 Latest Edition and Addenda.

3.2 REGULATIONS, CODES AND STANDARDS

3.2.1 Unless otherwise specified, the design, materials, fabrication and inspection of welded pressure vessels shall comply with ASME Code Section VIII, Division 1 latest edition.

OEM guidelines/standards may be adopted complying minimum requirements of this design philosophy of static equipment. Details of such selected guidelines/standards along with the list shall be furnished in the bid.

Unless specifically required, ASME Code stamp is not required.

Vessels will be sized according to inside diameter and 2:1 elliptical heads or hemispherical heads. Minimum inside diameter shall be 500 mm. Top cover shall be flanged if the ID is equal or less than 900 mm.

3.2.2 Vessels shall conform to the requirements of ASME Section VIII Division 1 & 2 Pressure Vessels codes and Technical Specifications mentioned in the design criterion.

3.2.3 Design of vessel skirt shall be based on seismic/wind/thermal considerations and fireproofing/insulation requirements.

3.3 ALLOWABLE STRESS
3.3.1 Vessel stresses during hydrostatic tests shall not exceed 90% of the minimum yield strength of the material.

3.3.2 Vessels to be hydrostatically shop tested in the horizontal position shall be supported adequately to keep local stresses in the shell not exceeding 90% of the yield strength of the material.

3.4 CORROSION ALLOWANCE

3.4.1 For an intermediate head, corrosion allowances shall be added to both sides.

3.4.2 For the inside of shells, heads, nozzles and manholes, the specified corrosion allowances shall be added.

3.4.3 For non removable internal parts, the specified corrosion allowances shall be added to both sides.

3.4.4 For removable internal parts, the specified corrosion allowances shall be added to one side only.

3.5.1 HEAD / DISHE D ENDS

a) Dished ends shall be of seamless construction. However, dished ends with one chordal weld seam are acceptable. In such cases, the chordal seam shall preferably be in the middle one third of the blank. Intermediate heat treatment, if considered necessary, shall be carried out by the LSTK Contractor.

b) Whenever a dished end is made of more than two plates, it must have a crown plate. Whenever a nozzle or a manhole is positioned at the centre of the dished end, the crown plate should be larger than the nozzle /manhole reinforcing pad.

c) Tori spherical heads shall be used for Pressures up to 6.86 bar (g). For tori spherical heads, ratio of Knuckle to Inside Crown Radius shall not be less than 6 %.

d) Beyond 6.86 bar g, heads shall be of ellipsoidal type having a ratio of major axis to minor axis 2:1 or hemispherical type. Alternatively, Hemispherical Heads with minimum weld joints may also be used.

3.6 Vessel skirts for carbon steel vessels shall be designed from the same material as the shell or the head. Vessel skirts for other than carbon steel vessels shall be the same material as the shell or the head for the top 500mm. All skirt supported equipment shall be provided with templates.
3.7 All nozzles above 24” NB shall comply with ASME B16.47 Series B (API 605).

3.8 Local vessel stress calculations for external structural attachments, such as platform clips, pipe support clips and lifting lugs shall be performed.

3.9 Vessels with skirts having eight or more anchor bolts shall be required to be supplied with an anchor bolt template. The template shall be of box type (no annulus type) to avoid problem during final erection and installation. The template shall have adequate strength against deformation.

3.10 Maximum permissible deflection for tall vessels/columns when subjected to design wind loadings shall not exceed 0.005 x Vessel height. For guidelines of Dynamic Wind Analysis refer Annexure-I.

3.11 For vessels, the minimum thickness of shell & heads, including corrosion allowance shall be as indicated below:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Shell Diameter (mm)</th>
<th>Thickness (Min.) mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CS / LAS</td>
<td>HAS</td>
</tr>
<tr>
<td>1</td>
<td>ID &lt; 500</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>501 &lt; ID &lt; 1200</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>1201 &lt; ID &lt; 2000</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>2001 &lt; ID &lt; 2600</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>ID &gt; 2600</td>
<td>10</td>
</tr>
</tbody>
</table>

CS = Carbon Steel  
LAS = Low-Alloy Steel  
HAS = High-Alloy Steel

3.12 Use of structural steel shall be limited to non-pressure parts only.

3.13 Horizontal vessels of large size and thin wall shell on saddle supports shall be investigated for buckling, local circumferential bending and shear stress. The method of L. P. Zick (Supplement to Welding Research, 1971) may be used for this investigation.
3.14 Manhole/hand hole/blind holes covers shall be equipped with davits or hinges to facilitate handling.

3.15 Manhole size of 24" is preferred. However, for shell dia. 1000 mm & above minimum size of manhole shall be 20" and for shell dia. 1000 mm & below 18" manhole size shall be minimum.

3.16 **INTERNALS**

3.16.1 For Tray design worst of the following conditions shall be considered:

   a) For tray design minimum loads of 100 kg/m\(^2\) in active areas and 320 kg/m\(^2\) in downcomer area shall be considered.

   b) For atmospheric, pre flash & vacuum distillation columns for trays under flash area uniform load of 500 kg/m\(^2\) shall be considered. This loading shall be applicable to first three trays above flash section.

   c) A concentrated live load of 150 kg at any point on the installed assembly independent of other design live loads.

   d) Maximum horizontal deflection at effective tray loading shall not exceed 1/900 of the span or 7 mm. whichever is less.

   e) Corrosion allowance shall be added to both sides of trays, support rings and other fixed internal non pressure parts.

3.16.2 All internal bolting shall be of corrosion resistant material.

3.16.3 Support for packing and internal shall be designed for the worst condition. In the condition of packing liquid hold up of minimum 20% of packing volume shall be considered. Tray support beams shall have height not exceeding 20% of distance between trays for diameter up to 2400 mm and 15% of the distance between trays for higher diameters.

3.16.4 Each tray shall be so designed as to ensure liquid tight construction. Each tray shall be provided with a man-way suitable for opening both from top and bottom unless otherwise specified.
3.16.5 MINIMUM THICKNESS OF INTERNALS SHALL BE ASfollowS:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Parts</th>
<th>CS &amp; LAS (MM)</th>
<th>HAS (MM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Chimney tray</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>2.</td>
<td>Tray decks partition, down comers, weirs pans etc.</td>
<td>3.5</td>
<td>2.0</td>
</tr>
<tr>
<td>3.</td>
<td>Tray support rings &amp; bolting bars</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>4.</td>
<td>Bubble caps</td>
<td>3.5</td>
<td>1.5</td>
</tr>
<tr>
<td>5.</td>
<td>Valves for trays</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>6.</td>
<td>Non-integral main &amp; secondary supporting beams</td>
<td>5.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Note: - 1) All bolting size shall be minimum of M10. All nuts shall be hexagonal.
2) Allowable stress criterion for design of internals shall be as per ASME Section VIII Div. 1

3.16.6 All necessary approval on Hydraulic design and internal drawings shall also to be obtained from Process Licenser as applicable.

3.16.7 All removable internals shall be designed so that they can pass through the vessel man-way internal diameter / shell flange if any.

3.16.8 The LSTK Contractor shall meet the process and hydrodynamic guarantee of towers along with their internals. All instruments including of special instruments required to verify the above requirements shall be arranged by the LSTK Contractor.

3.16.9 For an intermediate head, corrosion allowances shall be added to both sides.

3.16.10 Internal distribution pipes shall have flanged connections with gaskets unless otherwise specified. Internal pipes shall be divided into suitable lengths to pass freely through the vessel manholes and internal man ways, and shall be suitably supported from shells or tray decks.

3.16.11 Demisters shall be securely fastened to support ring by bolting or clamping.
3.16.12 Internals (trays, distributors, support beams) shall be so designed that any expansion of it wouldn’t affect shell deformation.

3.16.13 Hiccups load in vapour flow up the column shall be taken into account in the tray design.

3.17 CLADDING AND LINING

3.17.1 Cladding & lining is allowed only if specified in Process data sheet of OEM. Integrally clad metal and weld overlays shall not be considered as contributing to the strength of the vessel wall thickness of the Equipment. It should not be considered in the minimum thickness calculation.

3.17.2 Strip liners shall not be used in vessel shell for hydrogen service.

3.17.3 Cladded plates shall be supplied as per ASTM A 264 material specification. All clad plate shall be UT examined at the steel works in accordance with ASTM A 578 level S8.

3.18 ACCESSORIES

3.18.1 Clips for platforms, ladders and piping supports shall be furnished and attached to the vessel by the vessel manufacturer.

3.18.2 Top davits of vertical vessels shall be so designed and fabricated so that heavy valves around the vessels and internal parts of vessels can be removed and grounded without being interrupted by piping and steel structures.

3.18.3 INSULATION SUPPORT RINGS

1) Insulation support rings shall be suitable provided as per the specified insulation thickness.
2) Maximum longitudinal interval of insulation support rings shall be 3600 mm when preformed insulating material are used.
3) Stiffening rings may be used as insulation support rings.

3.18.4 Lifting lugs of appropriate size shall be provided to ensure complete safety during erection of the Vessel.

3.18.5 Grounding lugs shall be attached to the vessel support for the ground connection.
3.18.6 TEMPLATES

1) Templates for vertical vessels with skirts shall be provided for lying out of anchor bolts at site. The template shall have adequate strength against deformation. Template shall be identical to the Vessel Base Frame having double ring.

2) It shall be confirmed that markings of the bolt hole orientation on the templates coincides with those shown on the approved drawings.

3.19 PLATE LAYOUT

1) Shell plate shall be laid out so that there will be minimum of welded seams.

2) Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible.

3) Longitudinal welded seams on adjacent shell segments shall be separated by at least 4 times the wall thickness of the thicker plate but not less than 100 mm.

3.20 CONNECTIONS

3.20.1 Unless shown in data sheets, nozzles, manholes, and hand holes shall be ground flush and smooth inside the vessel. The edges of internal projections for both nozzles and manholes shall be rounded to a radius of 2 mm minimum. Reinforcement pads shall be external.

3.20.2 Main vessel seams shall not pass through openings for connections as far as possible. When unavoidable, the portion of the weld seam covered by a reinforcing pad shall be ground flush with the parent metal and 100% radio graphed prior to attachment of the pad.

3.20.3 All reinforcing pads shall be provided with at least one telltale hole of NPT 1/8".

3.21 HEAT TREATMENT

3.21.1 Fabricated vessels shall be post weld heat treated in accordance with ASME Code Section VIII, Division 1, and requirements specified in the data sheets.

3.21.2 The complete post weld heat treatment procedure including temperature and holding time shall be submitted to the Owner/PMC for review.
All machined surfaces shall be protected against scaling during post weld heat treatment.

3.21.3 All internal and external attachments, clips, insulation studs, name plate bracket, and the like shall be welded to the vessel before post weld heat treatment.

3.21.4 No welding, hammering or deforming is permitted on the pressure retaining parts after post weld heat treatment except as permitted by the codes or standards and when approved by the purchaser.

3.21.5 Simulation Heat Treatment for the Alloy Steel Material shall be carried out as per the CODE Requirement.

3.21.6 PICKLING

When specified, all internal / external surfaces of stainless steel shall be cleaned by pickling before hydrostatic test.

1) Care shall be taken so that stainless steel surfaces shall not be subject to any scratch or damage during pickling.
2) Weld scale and other foreign material deposited on the surfaces shall be removed.
3) Pickled surfaces shall be completely neutralized, and washed by freshwater

3.22 FABRICATION TOLERANCE

Dimensional tolerances shall be in accordance with the design codes or standards, whichever is more stringent.

3.23 PREPARATION FOR SHIPMENT

3.23.1 All vessels shall be drained, clean, and free of grease, oil, scale, weld spatter, and any other foreign substance.

3.23.2 All flange faces and other exposed machined surfaces shall be properly protected with substantial metal shields or covering against damage during shipment.
3.23.3 All inside surfaces and internal parts of carbon steel shall be coated with suitable rust preventive before shipment.

3.23.4 All openings shall be provided with metal closures.

3.23.5 Test holes of reinforcing pads for nozzles and manholes shall be plugged with steel or plastic plugs.

3.23.6 Vent holes of saddle pads shall be plugged with plastic sealant or hard grease prior to shipment.

3.23.8 All threaded connections shall be plugged with threaded round bars or covered with standard pipe caps of the same material as the equipment. Covers, flanges, gaskets, bolts, and nuts furnished by the fabricator shall be shipped in place.

Internals shall be tied or braced as necessary to avoid damage or dislodgment during Shipping and installation.

Baselines indicating four directions with figures of 0°, 90°, 180° and 270° shall be marked by paint on the shell. The paint colour shall be white for carbon steel and black for stainless Steel.

PART B - DESIGN PHILOSOPHY FOR HEAT EXCHANGERS

3.24 SHELL AND TUBE HEAT EXCHANGERS

3.24.1 General

a) SCOPE

This specification covers the minimum requirements for the design, materials, fabrication and inspection of shell and tube type heat exchangers.

b) The Design Philosophy for the Shell & Tube Heat Exchangers shall be read in conjunction with the Design Philosophy for Pressure Vessels, as per Part – A above.
3.24.2 All tubular heat exchangers shall be of the type specified and shall be designed for the service and performance conditions given in the specification or data sheets.

Design of the Shell & Tube Heat Exchangers shall be as per TEMA – R only. (TEMA Class ‘C’ may be used for auxiliary heat exchangers for rotating and packaged equipment exchangers.)

3.24.3 Gaskets shall be used for, Hydrogen & other lethal services only after recommendation by OEM.

3.24.4 Tubular heat exchangers of auxiliary component for machine units such as lube oil coolers is to be designed, fabricated, inspected and tested in accordance with the manufacturer's standards and ASME Code Section VIII, Division 1, provided written approval is obtained from the Owner/PMC.

3.24.5 Mean metal temperature of tube & shell be considered in the design of fixed tube sheet exchangers.

3.24.6 Parts such as tubes, tube sheets, floating heads etc. which simultaneously come in contact with both shell side and tube side fluids, shall be designed considering pressure acting on one side only or the combination of pressures, whichever results in higher thickness of parts.

3.24.7 Attachment of tube to tube sheet will be rolled and expanded (with seal welding), strength welded or seal welded as specified on data sheets. However, as a minimum following shall be adopted:

For tube sheet joint, tubes shall be expanded in grooved holes into the tube sheets. The expanding operation shall extend from the outer face of the tube sheets to a depth not < 90% of the tube sheet thickness. Welding shall be done in minimum two passes and each pass shall be DP checked. For tube-to-tube sheet joint GTAW (Gas-Tungsten Arc Welding) welding is required.

(A) Tubes shall be expanded and light seal welded if all the following conditions occur simultaneously:

a) Design pressure of shell/tube < 20 kg/cm2
b) Shell / Channel design temperature < 350 °C
c) Fluid not containing lethal substances.
c) Hydrogen partial pressure <7 bars

(B) Tubes shall be strength welded & light expanded for any condition other than listed under (A).

3.24.8 Procedure shall be qualified for tube-to-tube sheet joints. Mock-up test shall be carried out for heat exchangers having shell/tube side design pressure 100 Kg/Cm2 & above to establish all the requirements.

3.24.9 The sample for tube sheet and tube for mock up test shall be drawn from the same heat material from which the equipment shall be fabricated.

3.24.10 Process Shell and Tube Exchangers will comply with the requirements of ASME SEC VIII Div I & TEMA Class ‘R’. TEMA Class ‘C’ may be used for auxiliary heat exchangers for rotating and packaged equipment exchangers.

3.24.11 ASME Section VIII, Div. 1, Appendix “S” shall be considered mandatory for bolted flange connections.

3.24.12 All tube sheet for the exchangers shall be designed as per ASME Sec VIII Div 1 & also comply the requirement of section UHX of ASME Code.

3.24.13 Tube sheets in vertical exchangers shall be provided with drain and vent arrangement with threaded plug seal welded.

3.24.14 Exchanger saddle and foundation design shall include additional loadings generated from bundle pulling. The load shall be 1.5 times the bundle weight.

3.24.15 Shell side “hot” nozzles shall be located at the top of the shell at the channel end whenever possible.

3.24.16 Lifting lugs for heads or bonnets shall be specified where frequent dismantling is required.

3.24.17 Bundle weights shall be limited to 10 tonnes. In case the bundle weight increases by 10 Tones, Bidder shall take care necessary precaution in the design and fabrication of exchanger e.g. by providing rollers arrangement, support plates etc. to avoid excessive loading on shell while
Pulling of tube bundle, proper reinforcement in equipment support etc.

3.24.18 Saddle wear plate material shall be the same as the shell material.

3.24.19 Tube sheets and Girth Flanges shall be shall be of Forged Quality & Ultrasonically tested. It shall not have any segmental joint.

3.24.20 All heat exchanger tubes shall be seamless, cold drawn and formed from single length. CS tubes shall be normalized. LAS tubes shall be normalized and tempered.

3.24.21 The minimum radius of U tubes shall be not less than 2xOD of tube. Thickness of 2 inner most rows will be higher than other rows with minimum difference of 2 gauges.

3.24.22 For U tube bundle, the following requirements shall also be met:
   i) Each U tube shall be formed from a single straight length.
   ii) All U tubes shall be cold bent.
   iii) All C.S, C-Mo, Cr-Mo tubes shall be heat treated after bending.
   iv) Bent portion of all U tubes shall be examined by PT (Dye Penetrant test) and hardness check on four opposite points of bent portion shall be carried out.
   v) Unless otherwise specified, after bending each tube shall be tested hydraulically.

3.24.23 Where fixed tube sheet heat exchangers are specified, thermal stress shall be checked in accordance with the TEMA standard to determine if an expansion joint is necessary.

3.24.24 Tube to tube sheets joints shall be leak tested with air & soap solution at pressure of 2.0 kg/cm2 g wherever specified leak testing with halogen shall be carried out.

3.24.25 Impingement plates shall be provided if required by TEMA or indicated as a part of OEM’s requirement.

3.24.26 Impingement baffles shall extend at least 1.1 times of the inside diameter of nozzles, or nozzle inside diameter plus 50 mm, whichever is the larger.

3.24.27 For stack type of heat exchangers, nozzles shall be designed to carry the loads of shells after installation in operating conditions. Saddle shall be used for erection purpose only. However, If required no. of nozzles to act as support is not available, Saddle should be the primary support.
3.24.28 For stack type Heat Exchangers, complete assembly shall be hydraulically tested as a single unit except when the test pressures for individual heat exchangers are different.

3.24.29 Stacked exchangers shall have the lower shell(s) designed to withstand the superimposed load of the upper exchanger(s) full of water without distorting the shell and causing binding of tube bundle(s).

3.24.30 The lower fixed support of stacked exchangers shall be designed for bundle pulling loads for removal of the upper bundle.

3.24.31 When two or more exchangers are stacked, the entire stack shall be shop-assembled and checked for accuracy of saddle and nozzle fit-up.

3.24.32 Horizontal exchangers with removable tube bundles shall have the supports designed to withstand a horizontal pulling load equal to 150% of the bundle weight, applied at the centerline of the exchanger. The lower supports of stacked exchangers shall be designed for the loads of removing the upper bundle.

3.24.33 Bolts for connecting nozzles of stacked exchangers shall be removable without moving exchangers.

3.24.34 Removable tube bundle shall be provided with pulling York and suitable sliding arrangement.

3.24.35 Flow induced vibration analysis shall be carried out for all process heat exchangers.

3.24.36 Process Heat exchangers tubes shall be Eddy current tested at mill and the specified thickness of tube shall be minimum (and not average).

3.24.37 Floating head exchangers with test ring shall be procured as per TEMA for locating tube leaks. Drawing and calculations for test rings and test gland shall be provided by vendor for all Exchangers of applicable type.

3.24.38 Tube sheets shall have the corrosion allowance on each side. Tube Sheets from Plates shall not be used.
3.24.39 Slip-on flanges are not permitted for exchangers in hydrogen service, lethal service or low-temperature services below -29°C.

3.24.40 Pass partitions shall be provided with a weep hole of about 6 to 12 mm in diameter at low points of pass partitions.

3.24.41 Dowels or match marks shall be provided to prevent misassemble of floating head covers and channels with pass partitions, channel covers with grooves, and stationary tube sheets to shell flange.

3.24.42 In horizontal exchanger cross baffles and support plates shall be provided with notches for draining and venting.

3.24.43 Minimum SS 304 as MOC for tubes shall be used for Heat Exchangers having Cooling Water. All tubes shall be seamless only.

3.24.44 All heat Exchanger Tubes shall be Eddy Current Tested in addition to Hydro testing.

3.24.45 Copper & Copper Alloy tubes shall not be used for any Exchangers.

3.24.46 Corrosion allowance shall be added to the inside diameter of flanges. Gasket surfaces of flange shall have no corrosion allowance.

3.25 EXPANSION JOINTS

3.25.1 Where fixed tube sheet heat exchangers are specified, thermal stress shall be checked in accordance with the TEMA standard to determine if an expansion joint is necessary.

3.25.2 Expansion joints shall be designed for the most severe conditions of differential expansion that can occur during normal operations, start up, shutdown, or upset conditions.

3.25.3 Expansion joints shall be of the single layer standard one-piece construction unless otherwise approved by purchaser. Length of the bellow and preset shall be specified on the manufacturer's drawings.
3.25.4 For floating head type exchangers with single pass which are provided with bellows, permanent restraining bars or other means shall be fitted to allow the tube side of the exchanger to be pressure tested with the shell cover removed.

3.25.5 Expansion bellows shall be designed for min. 5000 cycle, as per TEMA.

3.26 GIRTH FLANGES

3.26.1 All girth flanges joining two parts with different design conditions shall be designed for the severer condition.

3.26.2 All girth flanges for carbon and low-alloy steel exchangers shall be integrally forged welding necks, unless otherwise specified in the data sheets. i.e. Girth Flanges shall be WNRF / WNRTJ type only.

3.26.3 Lined Flanges shall not be used.

3.26.4 All flanges designed with bolts greater than M 36 & above shall have sufficient clearance to permit the use of hydraulic bolt tensioning instrument. Bidder has to supply such hydraulic bolt tensioning instrument along with the supply of exchangers & its spares.

3.26.5 The Contractor shall guarantee tightness compatibility of closure designs. The differential thermal growth of gasketed joints of dissimilar materials (including gaskets) shall be considered.

3.26.6 All girth flanges shall be provided with jack screws to facilitate dismounting.

3.27 PASS PARTITIONS

3.27.1 All pass partitions shall have a gasket contact surface of 9 mm width minimum, and shall be machined to a common plane at the gasket face.

3.27.2 The depth of pass partition grooves in tube sheets and flat cover plates shall be a minimum of 5 mm. For alloy cladding or facing, there shall be at least 3 mm of alloy after machining beneath the pass partition groove or gasket face.
3.27.3 When space permits, pass partitions shall be continuously welded from both sides. In cases where space is too small for both side welding, weld shall be continuous on one side in so far as possible.

3.27.4 Pass partitions shall be provided with a weep hole of about 6 to 12 mm in diameter at low points of pass partitions.

3.28 TEST RINGS

Floating head type heat exchangers as well as U-tube type without full diameter stationary tube sheets shall be provided with test rings and test gland so that the exchanger shells may be pressure tested with the channels removed. Drawing and calculations for test rings and test gland shall be provided by vendor for all exchangers of applicable type.

3.29 HYDRO TESTING

3.29.1 Each heat exchanger shall be hydro tested in accordance with applicable codes and standards.

3.29.2 The shell side test shall be performed in such a manner that the Tube–to-tubesheet joints can be adequately inspected during testing.

3.29.3 Hydro Testing sequence & procedure for testing Exchangers having Lip Seal Gasket shall be approved by the Owner/PMC.

3.29.4 Stacked units shall be hydraulically tested in the fully assembled condition.

3.29.5 Air leak test shall be performed for tube to tube sheet joint for all exchangers. However Helium leak test shall be performed for critical heat exchangers/ wherever specified by OEM.

3.29.6 After testing, all exchangers shall be completely dried.

3.30 PLATE TYPE HEAT EXCHANGER

3.30.1 The plate type exchanger shall be designed in accordance with" API 662"
3.30.2 All plates shall be pressed from a homogeneous single metal sheet in one placing and normal thickness of plate being pressed shall not be less than 0.5 mm

3.30.3 Nozzle neck attachments shall be with full penetration weld. Set on nozzles are not permitted.

3.30.4 Lock washers shall be provided for all rotated nuts.

3.31 STORAGE TANKS

3.31.1 The following design codes shall be adopted for tank design as applicable:

a) API 620:- Design and Construction of Large Welded Low Pressure Storage Tanks.
b) API 650:- Welded Steel Storage Tanks for Oil Storage.
c) API-625 Tank Systems for Refrigerated Liquefied Gas Storage.

3.31.2 For Storage tanks the minimum thickness shall be based on stability considerations. Minimum thickness for roof & shell shall be 5 mm, and bottom plate 6 mm, excluding corrosion allowance.

3.31.3 Storage tanks up to 4 meter in diameter shall be shop fabricated items. Tanks with diameters greater than 4 meter shall be field erected.

3.31.4 Tanks constructed of stainless steel shall comply with API 650, Appendix S.

3.31.5 Shell seams shall be located to clear openings to the maximum extent possible in accordance with API 650.

3.31.6 Bottom plates may be lap-welded with the lap toward the direction of drainage. Buttwelded bottom plates shall be furnished when specified on the tank drawings or data sheets or when tanks are specified to have rubber lining.

3.31.7 For each surface in contact with product/vapor, the specified corrosion allowance shall be added to the required thickness of all load-carrying components including shell, roof, bottom and roof supports. & One-half the specified corrosion allowance shall be added to each surface of nonload-carrying internal components.
3.31.8. All walkways, stairways, and platforms shall be furnished with handrails on open or exposed sides.

3.31.9 Tanks having design temperature more than 100 °C shall have thermal isolation barrier (Suitable fire bricks) between tank bottom and foundation.

3.31.10 Anchor bolts shall be provided based on design considering wind/seismic loads, uplift due to internal pressure etc. However, tanks having diameter ≤10 meter shall be provided with anchor Bolts and shall be spaced at approximately 1.8M of circumference.

3.31.11 Maximum height of unstiffened shell shall be calculated based on the corroded thickness of shell courses. Section modulus of wind girders shall also based on corroded thickness of shell courses.

3.31.12 All storage tanks shall be designed as per code considering liquid height up to top curb angle of shell.

3.32 DESIGN & SELECTION OF RUBBER LINING

3.32.1 The type of rubber (i.e. Natural, Butyl, Nitrile, Ebonite, and Hypalon etc.), its minimum Thickness & hardness shall be decided as per design code/specification.

3.32.2 For vacuum service, the Triplex lining shall be adopted. It shall consist of 3 layers:

1st layer : 60 ±5 shore A
2nd layer : 35 ±5 shore B
3rd layer : 60 ±5 shore C

3.32.3 In general for all other services the preferred hardness of rubber shall be 65 ±5 shore A.

3.32.4 Lining up to 3 mm may be applied in single layer. Above this thickness it shall be applied in 2 or more layers. All sheets shall be drawned from calendaring machine only.

3.32.5 The surfaces which are to be covered with rubber shall be easily accessible & free from pitting or other physical imperfection.

3.32.6 Spark testing, bonding test & hardness test shall be done for Lining.
3.32.7 The internal surfaces requiring rubber lining shall be prepared by Tank Fabricator to suit rubber lining. All welds shall be ground smooth and radiused to min. rubber lining thickness. All welds shall be free from pin holes, pits, pockets and nipples. Porous welds are to be peened until tight. Since the internal surface preparation of the tank including roof (like grinding of the weldments etc.) is to be done by the tank contractor, the same surfaces will also be inspected and approved by the rubber lining contractor during tank fabrication and/or on handing over of the tank to him for rubber lining.

In the event of any surfaces found unsuitable, the tank contractor shall carry out necessary rectifications and make all surfaces suitable as per instructions of the rubber lining contractor or his authorised representative without any implication.

4.0 SPARE PARTS

4.1 COMMISSIONING SPARES

4.1.1 All commissioning spares shall be included by LSTK Contractor in their scope of supply and shall be part of the main equipment.

4.2 SPARES FOR 2 YEARS OPERATION

4.2.1 2 years operation spares shall be supplied by the contractor as per Section-10 of ITB.

5.0 DOCUMENTATION SCHEDULE

5.1 Documents shall be submitted as per “Documentation schedule” in Section-9 of ITB.

6.0 VENDORS LIST

All equipment shall be procured/fabricated as per approved vendor list (Section -15). Any equipment for which vendor list is not enclosed, the LSTK Contractor may furnish a list of their proposed vendors along with their references for supply of similar type of equipment along with bid. However all the additional proposed vendors shall have well proven track record and shall be subjected to consultant/owner’s approval.
ANNEXURE-1

CALCULATION METHOD

DYNAMIC WIND ANALYSIS (GUIDELINES)

FOR VERTICAL EQUIPMENT

Check of the towers for dynamic wind moments due to vortex shedding shall be performed based on following assumptions:

\[ V_{cr} = f \times \frac{D}{St} \]

- \( V_{cr} \) = Critical wind velocity
- \( D \) = Outside diameter of tower
- \( F \) = First natural frequency of tower considering foundation complete rigid (s-1)
- \( St \) = Strouhal number, may be taken as 0.15 for \( Re > 10^6 \) and 0.2 for \( Re < 10^6 \)
- \( Re \) = Reynolds number at critical wind velocity

For \( V_{cr} < 30 \text{ m/s} \) following shall be considered:

The tower shall be checked for additional moments due to vortex shedding in 2 cases.

1. Operating condition
2. Shut down condition

Dynamic wind moment shall be calculated as follows:

\[ M_d = P_d \times C_k \times S \times \frac{\pi d}{2} \times H \]

- \( P_d \) = Wind pressure at critical velocity = \( 0.5 \times \text{den}^2 \times (V_{cr})^2 \)
- \( C_k \) = Crosswind oscillatory force coefficient may be taken as \( 0.5 + \left(4 - \log_{10} Re\right)/5.7 \) for \( Re < 10^6 \) and 0.17 for \( Re > 10^6 \)
- \( d \) = The logarithmic decrement of damping. For towers with trays or packing it is estimated 0.035
- \( S \) = Surface on which dynamic wind forces are acting (height \(*\) diameter)
- \( H \) = Height from base ring of point of application for dynamic wind force
\[ \pi = 3.14 \]
\[ \text{Den} = \text{Density} \]

For tapered construction only the tip diameter shall be considered in calculation.

Moments to be considered for dynamic wind:

\[ M_{res} = \sqrt{(Md^2 + Mst^2)} \]

\[ Mst = \text{Static wind moment at critical wind velocity} \]

Only if \( M_{res} \) exceeds moments due to static wind or earthquake moments, it shall be considered for equipment design.
ANNEXURE-2
INSTRUCTION GUIDELINES

1.0 GENERAL

The min. Inspection to be carried out by Authorized approved Inspection agency:

1.1 VESSELS
a) All carbon steel plates shall be identified against mill-test certificates at the VENDOR’S works before commencement of fabrication.
b) Establish that welding procedure and welders are qualified and welding electrodes are approved before commencement of fabrication.
c) Check fit-up and witness chipping-back of welded seams.
e) Witness any crack detection, hardness checks, ultrasonic tests etc. which may be specified. (1)
f) Review radiographs and in case it is unsatisfactory re-radiograph. (1)
g) Witness hydrostatic test.
h) Dimensionally check and carry out final internal and external inspection for quality of workmanship.
i) Check that all material test certificates and, where applicable, heat treatment charts are in order. Ensure that VENDOR is familiar with the requirements regarding data books and ensure that the documentation is submitted without any delay.
j) Check internal lining of reactors and vessels (if applicable) to specifications.
k) Witness any further test recommended by Process Licenser/Inspection agency and/or OWNER.

Note (1): X or Gamma rays

1.2 VESSEL INTERNALS
a) Leak testing & final inspection only is required.
b) Check one tray of each diameter and type, mock assembled in the shop.
c) Spot check for interchangeability of parts, where applicable.
d) Ensure that any uncommon down comers are fully assembled and offered along with their respective trays.
e) Where new designs and/or new VENDOR's are concerned, check that any applicable leakage tests have been carried out on prototype.

f) Check that materials including welding electrodes are in accordance with the requirements of the order and all applicable specifications and standards.

1.3 STORAGE TANKS

a) Shell plates to be dimensionally checked (including diagonals for square-ness) before rolling to curvature.

b) All shell plates to be inspected and dimensionally checked after rolling to curvature.

c) Check material test certificates and ensure that all shell plates are clearly stamped with the cast and plate number, so that they can be identified against the relevant test certificates.

d) Check material test certificates for roof and bottom plates.

e) Select the spot radiographs, D.P & M.P test as per codes.

f) Review the radiographs. (1)

g) On completion of inspection of shell plates ensure that VENDOR provides a chart giving all plate numbers, tier by tier.

h) Inspect fabrication of all fabricated fittings. This is to include checking of material test certificates also.

i) Inspect tank gauging equipment.

j) For shop fabricated tanks, witness hydrostatic tests to applicable standards.

k) Check welding material electrodes.

Note (1): X or Gamma rays

1.4 HEAT TRANSFER EQUIPMENT

1.4.1 SHELL AND TUBE EXCHANGERS

a) All carbon steel plates shall be identified against mill test certificates at the VENDOR'S works before commencement of fabrication.

b) Establish that welding procedure and welders are qualified before commencement of fabrication.

c) Check fit-up and witness chipping-back of welded seams.

d) Wherever applicable, select spots for radiography.
e) Witness any crack detection, hardness checks, ultrasonic tests etc. which are specified in drawing, specification, data sheet etc.

f) Review radiographs. (1)

g) Witness all hydrostatic tests on shell and tube sides.

h) Complete dimensional check for stacked units. This is to be carried out in the full assembly stage.

i) Check that all material test certificates and where applicable, heat treatment charts are in order. Ensure that VENDOR is familiar with the requirements regarding data books and see that the documentation is submitted without any delay.

j) Witness any further test recommended by OEM/Inspection agency and/or OWNER.

Note (1): x or Gamma rays

1.4.2 VACUUM EQUIPMENT, INCLUDING CONDENSERS

a) Tests on ejectors to be witnessed.

b) Inspection and tests of condensers shall be done as for shell and tube exchangers as far as applicable in addition applicable codes and standards shall be taken into account.

c) Check all material test certificates for tubes, plates etc.

d) Check and witness other tests as applicable as per the Tender documents as well as applicable codes and standards, for rotary equipment.

1.4.3 STEAM GENERATORS AND BOILERS

a) Inspection of drums as for vessels.

b) Mill certificate shall be provided for tubes.

c) All mountings to be inspected and hydraulic tests witnessed at sub-supplier's works.

d) Check test certificates for all materials and identify the same at VENDOR'S works before start of fabrication.

e) Check fit-up and witness back chipping of weld seams.

f) Establish that welding procedure and welding electrodes as are qualified before start of fabrication and welding.

g) Steel stacks to be finally inspected and dimensionally checked. Spots for radiography to be selected, where applicable, and radiographs reviewed.

h) Ducting to be inspected for quality of workmanship and spot checked for dimensional accuracy.

i) Shop hydrostatic test to be witnessed and final inspection to be carried out on fully assembled packaged boilers.

j) Witness all tests applicable for steam generators.
SECTION : VI- 5.3.3

DESIGN PHILOSOPHY – ROTATING EQUIPMENTS

PLANT : STEAM GENERATION PLANT

PROJECT : INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA).
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# LIST OF ATTACHMENTS

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1.0 SCOPE

1.1 General

1.1.1 This Philosophy states that contractor’s scope of work shall include basic & detailed engineering, procurement, supply, manufacturing, fabrication, Inspection & testing, transportation, loading, unloading, insurance during transit, storage, construction, erection/ installation of all Mechanical Rotating Equipment with allied electrical, instrumentation and civil works, testing, mechanical completion, pre-commissioning, commissioning, performance guarantee test runs including total project management and handing over of ‘Steam Generation plant’ on LSTK and Single-Point responsibility basis at Talcher, Angul District, Odisha, India for M/s Talcher Fertilizers Limited (TFL).

1.1.2 In addition, all statutory rules & regulations in force shall also be complied with.

2.0 DESIGN PHILOSOPHY FOR MACHINERY

2.1 Codes and Standards

The Latest Edition of codes and standards as listed below shall be followed for design, manufacturing, inspection & testing of different machinery items.
Contractor to note that stand-alone OEM-standards for critical equipments are not acceptable.
Contractor to also note that requirement mentioned in API & other relevant codes & standards regarding any optional requirement or any bulleted points mentioned in the applicable codes, owner's decision shall prevail.

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**Performance Testing (ASME Codes)**

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**AGMA Standard**

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**NEMA Standards**

| SM 23 | Steam Turbine for Mechanical Drive Service. |

### 2.2 Design Life

All equipment shall be designed for a minimum service life of 25 years. Equipment shall have proven uninterrupted operation adhering to IBR prevailing norms & requirement for the industry.

### 2.3 Essential Project Reference Documents

The following documents shall be observed, and relevant aspects incorporated into specifications and datasheets:

- Process Description, Specifications and Data Sheets from Licensor
2.4 Regulations

Besides codes & standards, LSTK Contractor shall follow National Laws and Regulations in force together with Laws of state including statutory requirements as applicable.

2.5 Site Conditions

Site conditions shall be as defined in NIT Section 4.0.

2.6 Material of Construction

Generally Materials of construction shall be proven ones. However, applicable Codes & standards guideline to be adopted to the extent applicable.

Use of equivalent & superior material may be selected & shall be furnished with the offer along with chemical composition. LSTK Contractor shall furnish reference documents in the support of the same.

2.7 Quality Assurance & Control

2.7.1 The quality assurance shall be as per the approved procedures, test methods & facilities to be developed by the LSTK Contractor / vendor to ensure that the supplied equipment shall be of highest quality.

2.7.2 Quality Assurance (QA) shall mean the organizational set up, procedures as well as test methods and facilities developed by LSTK Contractor in order to assure that the machines & associated auxiliaries leaving LSTK Contractor’s/Vendor’s shop are of the highest possible quality i.e. either equal to or better than the requirement specified.

2.7.3 Quality Control (QC), shall mean all the tests, measurement, checks and calibration which are to be carried out in LSTK Contractor’s / Vendor’s shop in order to compare the actual characteristics of the equipment/unit/system with the specified ones, along with furnishing of the relevant documentation (certificates/records) containing the data or result of these activities.

2.7.4 LSTK Contractor shall submit a comprehensive description (manual) of QA/QC measures contemplated by him for implementation with regard to this specification. It is contractual obligation of the LSTK Contractor to develop and implement adequate QA/QC systems.
2.7.5 QA/QC system shall cover all products and services required for the complete machine unit as per scope of work including job sub contracted by the LSTK Contractor.

3.0 DESIGN REQUIREMENTS

3.1 General

3.1.1 All machines shall be directly coupled to their prime movers. V-Belt drives shall be avoided. If not, specifically mentioned, the drivers shall have rated output at least 10% greater than the power requirement of the driven equipment and also compliant to respective API codes / standards whichever is more stringent.

3.1.2 MOC used in the equipment required to be proven one.

3.1.3 All process pumps shall have Mechanical Seals. Single seals will be used in most cases, however, for ignitable or hazardous fluids, double, or Inside Wet and Outside Dry running seals will be used. Non-process/ non-critical pumps shall also have mechanical seal.

3.1.4 Special tools and tackles required for installation and maintenance shall be necessarily provided.

3.1.5 For approval of additional vendor (other than list enclosed with the NIT) during detail engg, LSTK contractor/ vendor has to furnish the reference list, copy of PO/ end user certificates for similar equipment's models (minimum 2 nos.) supplied in past for similar duty conditions. Reference list must contain at least the following: Fluid handled Capacity, Suction Pressure, Discharge Pressure, Model No., Power consumption, Client Name, Address, and Year of supply.

3.1.6 Lube oil system philosophy for critical / major equipment (ie. Turbines , BFW Pumps) shall have motor driven main oil pump, motor driven standby oil pump and DG power backed up emergency oil pumps with coast down tank in order to safe functioning of package. Lube oil system to also comply API-614.

3.1.7 Dedicated portable oil clarifiers with all hose & piping connection to be provided for major/ critical equipments (ie. Turbines , BFW Pumps).

3.1.8 Noise level for all rotating equipment shall be limited to 85 dBA measured at 1meter distance from the equipment.

3.1.9 All machines must have the details related to lubricants used written e.g. name of the lubricants, tank capacity (where it is used), level measurement with high - low marking, flow direction on the oil pipe line, trip values for oil pressure low, auto start pressure etc. marked at appropriate locations.

3.1.10 Lubricants storage section having minimum emergency stock of all required lubricants to take care of any emergencies. It shall have lubrication drum loading / unloading facility, for transportation of oil drums with associated facilities like a electrical or
hand operated oil pump (For transfer of lubricant to machines), with oil collection pits in case of any spillages with adequate illumination.

3.2 Centrifugal Pumps:

The process pumps shall be designed as per API 610, latest edition. The pumps shall be of robust design to ensure long service life and minimum maintenance requirement. The pumps shall be designed for easy access for inspection and maintenance. In addition to codes & standards, following points shall also be applicable:

3.2.1 All pumps shall have continuously rising head curve from any specified operating point to shut off point. Pumps running in parallel shall have equal head rise to shut off point.

3.2.2 The pumps should have stable operating characteristics. The pump head at shut off shall be approximately 110% of head at rated capacity and not exceeding 120%.

3.2.3 Best efficiency point shall be as close as possible to normal operating point.

3.2.4 Impellers of multistage pumps shall be secured positively against axial movement.

3.2.5 For multistage pumps, a lateral critical speed analysis shall be carried out.

3.2.6 Pumps with centre line support shall be provided for pumps handling fluids of operating temperature more than 177°C.

3.2.7 Pumps shall not be offered or supplied with minimum impeller diameter. Selected impeller diameter shall be with a margin of at least 5% from minimum impeller diameter.

The maximum calculated axial load shall not in any operating condition exceed 50% of bearing manufacturer's load rating.

3.2.8 Shim pack dry flexible coupling from reputed coupling manufactures like M/s Turboflex, Euroflex & KOP Flex shall be used. Coupling guard shall be non-sparking for pumps located in hazardous area.

3.2.9 Mechanical seal of John crane / Flowservel / Eagle-Burgmann make shall be provided.

3.2.10 Bearing Isolators of reputed & established make shall be provided for equipment & its driver motor/ turbine & gear box.

3.2.11 For API governed pumps with forced lubrication system, the lubrication system shall be designed as per API 614 latest edition as covered in clause no. 3.1.6. Steam turbine driven Cooling water pumps, if any, shall also have lube oil system as prescribed in clause 3.1.6.

3.2.12 All continuous and Intermittent running pumps shall have a stand-by pump.
3.2.13 Cooling water pumps shall be horizontal split casing type with mechanical seals. Emergency CW pumps shall also preferably be horizontal split casing type with mechanical seals.

3.2.14 BFW Pumps shall be API 610- BB5 type and OEM shall have proven operational experience for the same. MOC for BFW pumps shall be minimum S-6 material class as per API 610. Condensate handling pumps shall also be API compliant.

3.2.15 NPSH test shall be carried out for all critical pumps (BFW Pumps, CW Pumps) including Stand-by also irrespective of margin between NPSHA and NPSHR. For other misc pumps NPSH test to be carried out where margin between NPSHA and NPSHR is less than 1 mtr.

3.3 **Reciprocating Pump / Metering Pumps** :

Reciprocating pump shall be designed as per API 674 latest edition and metering pump shall be designed as per API 675 latest edition.

3.3.1 The metering pumps shall be suitable for continuous capacity variation. The capacity variation should be possible while the pumps are working.

3.3.2 Hollow plungers are prohibited. Repacking should be possible without removing plunger from the cylinder.

3.3.3 Enclosed crank cases, gear units and similar mechanisms shall be sealed. Removable covers shall be provided for inspection, cleaning and minor adjustments of parts.

3.3.4 Performance testing shall be carried out in accordance with ASME PTC 7.1/ Hydraulic Institute Standard.

3.3.5 All accessories i.e. gear box, coupling etc. shall be inspected and tested as per the applicable codes / standards.

3.3.6 Instruments and control panels shall be tested and inspected as per the applicable instrument specifications.

3.3.7 Electric motor drivers shall be tested and inspected as per the respective motor specification sheet and the applicable engineering standard specified.

3.4 **Steam Turbine** :

3.4.1 Steam turbine as drive for BFW pumps shall be designed as per API 611 (general purpose), latest edition, if applicable.

3.4.2 Steam Turbine Casings:

   a) The casing shall be designed for hydrostatic test pressure of at least 50% more than maximum working pressure. The casings shall be free from sharp corners; sudden changes in section and other features, which may result in unnecessary stress concentration.
b) Each turbine casing shall be provided with efficient draining facility. The parts of the turbine casing, which may come in contact with wet steam in normal operation or during start-up, shall be provided with an inter-stage drainage system whereby extracted water shall be prevented from re-entry to the blading and shall be transferred to either a convenient heater extraction branch or the condenser. The casing drains shall be provided with temperature sensing devices to ensure proper evacuation of drains.

c) Bolts, nuts and studs used for the turbine casing flanges and main turbine valve bonnets etc., shall be with threads and of special alloy steel appropriately heat treated. Provision shall be made for electrical heating of the bolts to facilitate setting & loosening. In addition, the supplier shall indicate the design feature incorporated to prevent the seizure of nuts and studs and features, which will facilitate their easy removal after operating the machine. Bolts shall be designed to distribute the load evenly on all the threads without stress concentration. All the joints shall have sufficient flexibility to remain tight with rapid changes of temperature. Before shipment, each bolt shall be thoroughly examined and inspected to ensure freedom from any defects.

d) Necessary quantities of assorted bolt heaters, torque or other wrenches, extensometers, bolt thread lubricator shall be included in the proposal as part of maintenance tools and tackle. The proposal shall specify bolt loading and strains and shall state the estimated period in which retightening or replacement of the bolts will be required and shall furnish detailed data, method and instruction for this purpose.

e) The supports of the turbine on the foundation shall be designed considering the expansion and contraction of the machine during thermal cycling. Axial movements shall be allowed by anchoring at one point and central position shall be maintained by fitted keys.

f) The casing design shall permit inspection of all the bearings without dismantling the casing.

g) All special insulation, paints, sprays along with equipment required to apply these on steam turbine shall be included in the Contractor's scope of supply.

h) The steam extraction branches shall be located on the lower half casings.

3.4.3 Steam Turbine Rotors:

a) Forged alloy steel rotor shall be provided.

b) Ensure uniformity of material composition and strength by examining adequate number of test specimen.

c) Ensure heat stabilization of the rotor as per ASTM-A472, or approved equivalent standards.

d) Ensure static & dynamic balancing of composite rotor and blade assembly.

e) Maximum permissible vibration measured at bearing housing will be as per ISO 10816 and API .

f) Critical speed of composite rotor and blade assembly shall not be within ±20% of operating speed. LSTK contractor to furnish studies carried out for combined
critical speeds for offered TG set. Further, LSTK contractor shall furnish at least two such studies for earlier supplied TG sets along with their field data, in order to establish the validity of such studies.

3.4.4 Turbine driver and driven equipment shall be mounted on a common base plate unless otherwise specified. Turbine manufacturer shall provide dimensional and load data to driven equipment supplier for design and supply of common base plate by driven equipment supplier.

3.4.5 Piping connected to turbine shall be designed to limit forces, stresses, vibration and noise to acceptable limits as per relevant codes on account of flow, pressure and temperature conditions of fluid flowing through them. Adequate anti-vibration supports, springs, etc. shall be provided to limit vibrations and accommodate thermal movements.

3.4.6 Noise level shall be limited to 85 dBA at one metre distance by provision of silencers/acoustic insulation and/or noise hood as may be necessary.

3.4.7 Special provisions for emergency lube oil supply to bearings and gears shall be made in case of power failure. This shall require overhead reserve oil tank to supply lube oil at adequate pressure when there is breakdown of power. Necessary control circuit shall also be provided for this system.

3.4.8 Efficient Shaft sealing of reputed make to be provided to prohibit leakage of steam from the turbine. Suitable bearing Isolators of reputed make shall be provided.

3.4.9 Shim pack dry flexible coupling from reputed coupling manufactures like M/s Turboflex, Euroflex & KOP Flex shall be used. Any other established equivalent coupling may also be proposed by Vendor for owner's approval along with PTR. Coupling shall comply to API 671.

3.4.10 All main and auxiliary piping shall be laid out in neat fashion to allow adequate clearances for operation and maintenance (Min 900 mm), and head rooms (Min 2200 mm) for working personnel. Design shall allow maintenance of parts without dismantling piping or supports.

3.4.11 The turbine and auxiliary equipment shall be designed for outdoor operation totally unprotected from weather, but due to grouping of equipment they may be installed in a common building for convenience in operation. Several compressors, turbines shall be placed at common operating platform and maintained by an overhead travelling crane. The crane capacity shall be decided based on maximum weight of maintenance part to be lifted. A loading bay shall be kept open for erection and maintenance purposes.

3.4.12 Local control panel shall be adjacent to turbine for easy operation.

3.4.13 All valves and controlling devices shall be within easy reach for convenient and quick attention by operators.
3.4.14 Turbine auxiliaries such as lubrication circuit with tanks and exchangers, stage heaters, safety valves, etc. shall be arranged with economising space and provided with suitable devices for removal and maintenance.

3.5 **Oil Purification System/ Centrifuge**:

3.5.1 Dedicate Portable Oil Purifier shall be provided for major/critical equipments as applicable. The oil purifier/centrifuge should be portable with suitable pipings/fittings which can be moved and fitted to the number of equipment’s intended.

3.5.2 Purification system consisting of:
- Unit oil tank drain piping through level indicating type seal box.
- One (1) centrifuge oil purifier with drive and accessories.
- One (1) electrically heated water bath oil heater.
- Two (2) dirty oil pump with drive.
- Two (2) clean oil pump with drive.
- One (1) polishing filter.
- Necessary interconnecting piping, valves, strainers, flow meters, gauges, hangers, supports, controls, instrumentation etc. shall be provided with purifiers.
- All electrical accessories, wiring, starters, switches etc. including one control panel complete with annunciation system. All base plate, foundation bolts, sleeves etc.

3.5.3 **Performance Requirement**:

a) Each purification system shall have a flow capacity per hour of 20% of the total oil in the unit oil system (i.e. the total quantity of oil required to fill the oil system of turbo-generator unit).

b) The oil at the outlet of the polishing filter shall not contain any free moisture & particles of size higher than two (2) microns.

c) Oil at the outlet of centrifuge shall not contain free moisture and particles of size higher than five (5) microns when the oil is heated to a temperature of not more than 65°C. The equipment shall be suitable for continuous operation round the clock.

d) Shall serve continuously as per steam generation plant stipulated period of turnaround philosophy described in NIT.

e) The centrifuge shall be complete with drive motor and transmission shall be through gears.

f) The centrifuge shall be equipped with suitable anti-seal loss device to prevent loss of oil with heavy phase drain beyond the limit guaranteed by the supplier.

g) The material for the rotating parts of the centrifuge shall be high-grade stainless steel AISI-316 or equivalent. Other parts in contact with the oil shall be of stainless steel or of other corrosion resistant material. The Outer casing may be carbon steel construction. The construction shall be vapour tight.

h) The arrangement of the assembly must enable easy removal of the collected solid particles within a short time.
i) The centrifuge shall be equipped with sight glasses both for the purified oil and the separated water from collecting pan.

j) The mounting arrangement of rotating parts must be designed to eliminate undue imbalance and vibration. The rotating parts shall be statically & dynamically balanced.

k) Necessary annunciation, interlock and safety devices shall be provided for safe and trouble-free operation.

3.6 Centrifugal Fans:

3.6.1 Centrifugal fans shall be designed as per API 673, latest edition for critical services i.e. FD and ID fan for Boilers. For non-critical services manufacturer’s standard based on national / international standards may be applicable.

3.6.2 Forced and induced draught fans shall be coupled to drivers through shim pack dry flexible coupling, and the complete assembly shall be mounted on a single base frame.

3.6.3 First critical speed of the rotor shall be higher than 120% of rated speed.

3.6.4 Capacity control shall be achieved by means of dampers (Preferably on suction side) specially for constant speed fans.

3.6.5 The fan casing shall be suitably split such that impeller assembly can be removed for maintenance without disturbing inlet and outlet ducting.

3.6.6 SS bolts and nuts shall be provided for the split casing joints of fans for corrosive service also must be suitable for prohibiting the undesirable elongation and loosening of fasteners during operation.

3.6.7 The drive motors of the fans should be designed with additional capacity to take care of surge loading. However Motor rating shall be minimum 125 % of Fan shaft power up to 22 KW, 115 % of shaft power for shaft power between 22 – 55 KW and 110 % of shaft power for shaft power above 55 KW.

3.6.8 Bearing shall be preferably oil lubricated.

3.7 Centrifugal and Rotary (Screw) Compressors (if applicable):

3.7.1 Compressors (for air services) shall be oil-free type and shall be supplied as per the requirements of API 672 / Equivalent national or international standards. Screw Compressor shall be conforming to relevant IS/ISO standards.

3.7.2 Compressor filtration hood and suction piping shall be SS material only. Air compressor suction to be provided with suitable measures to avoid moisture ingress during rainy season.
3.7.3 All machines shall have stable operating characteristics. The head generated shall rise continuously from choke point to surge point.

3.7.4 Vendor shall provide maximum range of capacity control without air venting. However a surge control shall also be provided so that the operation at low capacity is not limited.

3.7.5 Compressor shall be designed to deliver the rated head (i.e. rated discharge pressure) @ rated capacity without negative tolerance. Vendor to consider pressure losses in the air intake system & compressor discharge up to after cooler while performing compressor sizing.

3.7.6 The BKW at rated conditions shall be guaranteed with zero positive tolerance.

3.7.7 Driver rating shall be at least 110% of Compressor rated BKW at rated condition or BKW at unthrottled min. ambient temp. & maximum Atm. Pressure, whichever is higher.

3.7.8 Extra/Over-design margin in Compressor capacity shall be as per process design philosophy of NIT.

3.7.9 Compressor package shall be provided with Hydrodynamic Radial & Thrust bearings and Pressurized lubrication system (as applicable) meeting requirements of relevant codes & standards.

3.7.10 Couplings shall be non-lubricated, all metallic flexible type with spacer with a non-sparking coupling guard. The coupling shall have min service factor of 1.5 over the maximum capability of compressor.

4.0 INSPECTION & TESTING

Machines shall be inspected by nominated / approved Third Party Inspection Agency (TPIA) as indicated in commercial part of NIT. The Inspection and testing shall be in accordance with the all relevant codes, standards, specifications, including the minimum guide line given in Annexure – 1 (attached). Applicable codes / standards for inspection & testing to be duly followed and mentioned in ITP/QAP documents by LSTK contractor.

4.1 All testing accessories, measuring instruments including NDT testing equipment, etc. shall be arranged by LSTK Contractor. DM water shall be used for hydro testing of the equipment.

4.2 Job driver / Motor shall preferably be used for MRT and performance test. However, any limitation regarding use of Job driver / motor shall be submitted to owner with due justification for owner’s approval during detail engg on case to case basis.

4.3 String test to be performed at Vendor’s shop. If not possible at vendor’s shop, then LSTK Contractor may perform the same at Owner’s site. However, Contractor shall submit to owner due justification for owner’s approval during detail engg on case to case basis.
4.4 Witness test (by TPI) for all rotary equipment including stand-by to be done. LSTK contractor shall furnish project specific QAP/ ITP (Inspection Test Plan) for all equipment during detail engg for owner's approval.

4.5 In general, following tests shall be conducted for all rotating equipments:
   - Material test
   - Non-destructive test
   - Hydrostatic test for all the pressure containing parts
   - Dynamic balancing of rotor
   - Over speed test of impeller / Rotor
   - Helium leak test of compressor casing (if required as per API Code)
   - Mechanical running test
   - Barring over check for reciprocating compressor
   - NPSHR test for pumps
   - Performance Test
   - String Test
   - Disassembly Test
   - Impeller / casing inspection
   - Vibration Test

The tests required to be conducted and witnessed shall be specified in the equipment data sheet by LSTK contractor. Disassembly test for Fans, Blowers & small Pumps can be waived –off in case no problem occurs during mechanical / performance Test.

5.0 SPARES

5.1 All erection, pre-commissioning & commissioning spares including spares consumed during testing / PGTR till handing over the plant to owner shall be supplied by LSTK Contractor free of cost. Any unused commissioning spares shall be owner's property.

5.2 Mandatory spares shall be supplied by the LSTK contractor as per NIT.

5.3 LSTK Contractor to also furnish separate recommended list of 2 years operation & maintenance spare part list along with budgetary offers, valid for 2 years from the date of submission of offer for owner’s consideration. Recommended spares and their quantities should take into account related factors of equipment reliability, effect of equipment downtime upon production or safety, cost of parts and availability of vendor’s service facilities around the proposed location of equipment.

5.4 Detail List of special tools & tackles shall be furnished by the LSTK bidder along with the bid and shall be in scope of supply of the LSTK contractor.
6.0 PAINTING

6.1 All exterior non-stainless steel surfaces subject to atmospheric corrosion with the exception of machined surfaces shall be epoxy or polyurethane painted.

6.2 All exterior machined surfaces shall be coated with suitable rust preventives.

7.0 VENDORS LIST

All equipment shall be procured / fabricated as per approved vendor list enclosed with NIT.

LSTK Contractor to also note that any other vendor or item which are not mentioned in NIT, successful LSTK bidder may furnish list of proven sub-suppliers with PTR subject to owner’s approval during detail engg. Document (PTR) shall be in English language only.

8.0 LSTK CONTRACTOR / VENDOR DOCUMENTATION:

Drawings & Documents of machinery items/ rotating equipment shall be as mentioned in NIT.

Contractor to furnish Complete List of all rotating equipment with their quantity, tag numbers and Power consumption along with the bid. Material Requisition(MR) for all machinery/ equipment to be submitted by contractor for PMC’s/Owner’s review & approval. Owner’s/ PMC comments are to be duly incorporated by contractor and afterwards contractor shall proceed with procurement activity with respective OEMs. Technical Bid Evaluation (TBE) documents are to be furnished by bidder to PMC’s/Owner’s for information.

The un-priced or priced copies of purchase requisition / purchase orders detailing both technical and commercial aspects for all items shall be submitted to PMC’s/Owner’s for review & comments. Contractor to proceed for placement of order on corresponding successful OEM only after receipt of CLEARANCE from Owner against the subject PR/PO.
ANNEXURE-1

INSPECTION & TESTING GUIDE LINES – ROTATING EQUIPMENT

1.0 SCOPE

This document covers the minimum guide lines for the Inspection & Testing for the rotating Equipments.

All rotating Equipments shall be inspected by Third Party Inspection Agency. The Inspection and testing shall be in accordance with the all relevant codes, standards, and specifications as specified in Specification sheet. Applicable codes / standards for inspection & testing to be duly followed and mentioned in ITP/QAP documents by LSTK contractor.

2.0 PUMPS, TURBINES AND GEAR BOX

2.1 Pump and turbine casings to be identified against foundry test certificates and thickness checked to conform to approved drawings.

2.2 Witness hydrostatic test on casings.

2.3 Dynamic balancing of rotor

2.4 Witness running tests on pumps including N.P.S.H. where applicable.

2.5 Non-destructive test

2.6 Strip inspection of pumps on completion of running tests. Wearing surfaces to be checked and recorded. As a general principle, mechanical seals will not be dismantled after running tests. This necessity will be discussed on a case to case basis if abnormal noise or temperature has need records during testing. All materials to be checked against test certificates or VENDOR'S bill of materials.

2.7 Final inspection and dimensional check of pump (including driver, when mounted on base plate).

2.8 For Gear boxes all requisite test regarding material inspection viz. Radiography, UT, PT, MPI to be conducted.

2.9 Mechanical run test along with Full speed/ Full or part load test , Full torque/ slow roll test, Sound level test to be performed and witnessed for gear boxes.
2.10 For steam turbine drivers, hydrostatic test on pressure parts to be witnessed.
2.11 Running tests on steam turbines to be witnessed.
2.12 If spare rotating assembly is ordered, running test to be conducted and witnessed for spare rotor also as applicable for the job rotor.
2.12 Final inspection and dimensional check on steam turbines to be done.
2.13 Check all test certificates.

3.0 COMPRESSORS, FAN & BLOWERS AND DRIVERS

3.1 Material of casings or cylinders to be checked against test certificates.
3.2 For fabricated casings, inspection shall be as per codes & standard mentioned in NIT.
3.3 Hydrostatic test on casings or cylinders to be witnessed.
3.4 Dynamic balancing of rotor
3.5 Non-destructive test
3.6 For fabricated impellers, welding procedure and welder's qualifications to be established and impellers to be inspected before assembly. Impellers overspeed, NDT after overspeed and dimensional inspection.
3.7 Ensure that overspeed tests on impellers have been carried out and related certificate for dynamic balancing of impellers and subsequently the complete rotating assembly shall be provided. The over speed test shall be carried out to prove the impeller proper balancing and relevant certificate shall be provided.
3.8 Witness leakage test on lube oil tank and carry out internal and external inspection. Tank to be finally inspected after internal coating and/or painting.
3.9 Inspect prefabricated lube oil piping.
3.10 Witness performance tests shall be done and check all safety and alarm devices when contact instrumentation is fitted.
3.11 If spare rotating assembly is ordered, running test to be conducted and witnessed for spare rotor also as applicable for the job rotor.
3.12 Strip inspection on completion of running tests. To include examination of all running surfaces, checking of critical clearances, and examination of lube oil filters in the tests.
3.13 Final inspection and dimensional check of compressors mounted on base plates.
3.14 Gearing, pinion forgings and main wheel forgings or castings to be inspected at forge shop or foundry.

3.15 Any dynamic balancing of gearing rotors to be witnessed.

3.16 Fabricated gear cases to be inspected at sub-supplier's works.

3.17 Light or full load running tests, as specified to be witnessed on gearing.

3.18 Final inspection and dimensional check of gearing to be done at manufacturer’s works.
SECTION VI – 5.3.4

DESIGN PHILOSOPHY -
COAL AND ASH HANDLING SYSTEM

PLANTS: STEAM GENERATION PLANT

PROJECT: INTEGRATED COAL BASED FERTILISER
COMPLEX AT TALCHER, ANGUL DISTRICT,
ODISHA (INDIA)
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1.0 PURPOSE

This document lays down the guidelines for design, engineering, erection, commissioning, inspection & testing requirements for Coal and Ash Handling System of Steam generation Plant of M/s Talcher Fertilizers Limited for Coal based Fertilizer Plant.

2.0 CODES AND STANDARDS

The design, manufacture, inspection and testing of Coal and Ash Handling System for Steam generation Plant shall comply with all the currently applicable statues, regulations and safety codes in the locality where the equipment is to be installed. The equipment shall confirm to the latest edition of the following standards & codes. Other internationally acceptable standards/codes, which ensure equal or higher performance, shall also be accepted.

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3.0 RAW MATERIAL HANDLING SYSTEM

3.1 COAL CRUSHING AND SCREENING

LSTK’s contractor scope shall be started from Coal Crusher House of Coal Gasification Plant. Coal (-) 30mm / fluxant (-) 30mm shall be received through conveyors from Coal Crusher House (Coal crusher house of Gasification plant not in LSTK’s contractor scope) of Coal Gasification Plant and shall be transferred to Coal/Fluxant feeding Bunkers of Boilers through series of conveyors, Crushers/Vertical Rollers Mills, screens, feeders etc. Capacity of belt conveying system at battery limit of Steam Generation Plant is 1000TPH (Rated)/ 1200 TPH (Design). Bidder to design Material Handling system as per steam generation plant process requirement for two shift operations i.e. 14 hours to fill all raw materials to steam generation plant.

The size of the coal / fluxant received is normally (-) 30 mm from Coal Crushing House of Coal Gasification Plant which is not in bidder’s scope. The received coal/fluxant is sized in crusher house/Vertical Roller Mills from (-) 30 mm to size as required by boiler manufacturer. Crushing system/Milling system (Crusher/Vertical Roller Mill, screen, vibrating feeder & conveyors, gates etc.) is in scope of LSTK contractor.

Travelling tippler conveyors/shuttle conveyors shall be used at the bunkers inlet flange to feed crushed/sized Coal/Fluxant to respective bunkers.

In case of CFBC Boiler, 1 working + 1 standby crusher for coal and 1 working + 1 standby crusher for fluxant shall be considered for Steam Generation Plant. In case of PFBC Boiler, dedicated milling system shall be considered for each boiler of steam generation plant.

Dedicated coal bunker and fluxant bunker shall be used to feed each boiler. The capacity bunker for coal shall be minimum 12 hours of operation and the capacity of bunker for fluxant shall be minimum 24 hours of operation for each boiler. Rack & pinion gate/Rod gate/suitable arrangement and weigh feeder shall be installed at bottom of each bunker for measurement.
of flow rate of coal / fluxant.

The Project shall be so designed and the equipment shall be sized so that the specified material through-put is achieved without equipment overloading, material degradation or spillage.

All erection & commissioning spares including spares consumed during various tests including performance guarantee test, till handling of all material handling equipment to owner shall be supplied by contractor free of cost. Any unused commissioning spares shall be owner’s property.

Mandatory spares shall be supplied by the contractors as per NIT.

Contractor to also furnish separate recommended list of 2 years operation & maintenance spare part list along with budgetary offer, valid for 2 years from the date of submission of offer for owners consideration.

4.0 TECHNICAL SPECIFICATION

4.0 BELT CONVEYORS

1. Conveyor capacity shall be such that it shall be adequate to handle raw material for Steam Generation Plant capacity. Design capacity shall be considered as min. 20% more than the rated capacity.

2. All conveyors shall include adequate structural supports, transfer towers, all drives, pulleys, idlers, chutes, belting, skirt boards, belt cleaners, hold backs(for inclined conveyors), emergency switches, protective devices etc.

3. Conveyor supporting structure should be closed gallery with walkway on both sides.

4. All the equipment of coal handling system shall be designed to operate on continuous duty i.e., 24 hours per day and 365 days in a year.

5. All conveyors outside buildings shall be in enclosed galleries having main walk-way of 1100 mm clear width on one side and 750 mm clear width on other side (maintenance way) of conveyors.
6. All belt conveyors shall have suitable gravity take-up unit, except material weigh feeder which have short length and wherever agreed by owner/consultant.

7. The belt speed shall be optimum so as to minimise material degradation, spillage and generation of dust. Belt speed shall not exceed 2.5 m/sec.

8. Continuous belt weigher shall be installed on conveyor at suitable locations. Display of this weigher would be connected through control panel.

9. Electro Magnetic separator arrangement of adequate capacity to be provided at suitable location to separate any unwanted particle from the feed coal and fluxant.

10. All the conveyors shall be provided with identical designed frame size, roller size, pulley size etc. as far as possible to have better interchangeability and reducing the inventory spare parts.

11. The belting shall be of either synthetic fabric such as Nylon-Nylon / Polyester Polyamide, Steel Cord etc. with rubber covers of adequate flexibility to give a troughing angle of 35 deg. For all the conveyors the number of plies, cover thickness, factor of safety etc. shall be as per the recommendation of belt manufacturer of adequate strength.

12. Conveyor drive shall be directly coupled through suitable helical gear box.

13. Minimum service factor for coupling shall be taken as 2.0 on the absorbed power.

14. Minimum service factor on gear boxes shall be taken as 1.5 over the absorbed power.

15. All conveyor belts shall be fitted with belt cleaners/scrapers which will be located between the head and snub drums, on the return belt side. All conveyors’ belts shall be fitted with multi-blade sprung type external belt scraper below head pulley and V-type internal belt scraper. All cleaned material from the belt shall fall within the head chute.

16. The skirt boards and sealing with overlapping block design shall be provided with labyrinth seals.
17. All equipment’s / assemblies shall use antifriction bearing fitted in Plummer block.

18. All discharge Chutes shall be lined with material Tiscral /Sailhard (Adequate thickness minimum 12 mm).

19. In Belt conveyor system, Deck plate shall be provided 4 m length (min.) at receiving end and 2 m length (min.) at discharge end.

20. In Double stream conveyors central walk way width shall be minimum 1100mm.

21. Self-aligning training idler spacing to be considered as maximum 15m for carrying side & maximum 30m for return side.

22. Return idler shall be with rubber rings or rubber lined. Vertical guide rollers shall also be rubber lagged type.

23. Impact idlers (minimum 5 nos.) shall be provided at loading points at spacing of 300 mm. Impact idlers shall be of rubber lagged type.

24. All pulleys shall be lagged in herring-bone pattern. Head/Drive pulleys shall be lagged with 12 mm thickness Neoprene and Tail & Snub pulleys shall be lagged with 12 mm thickness Neoprene.

25. All diverter & gate shall be electrically or pneumatically operated.

26. For safety of conveyors and personnel, all conveyors shall be provided with safety switches like zero speed switch, belt sway switch and pull cord. In addition to these there shall be provision of audible warning (Hooter) of starting of conveyor.

27. Suitable hold back devices for preventing running back of the conveyor belt in case of conveyor being stopped in loaded conditions due to power failure or during normal operational delays shall be provided to give positive protection. The hold back shall instantaneously engage without shock and be capable of protecting equipment and personnel. It shall be released instantly when ‘power’ resumes or the ‘delay’ is removed. The holdback devices shall be integral with gearbox.
28. All Conveyor galleries shall be provided with dust sweeping chutes covered with removal chequered plates. There shall be one dust hopper for each walkway of gallery and the same shall be provided at the middle of walkway near trestle location.

29. All over ground conveyors are provided with covered galleries. Crossover shall be provided at 100 m intervals (no cross over for conveyors less than 100 m). Gallery shall be designed to accommodate cable & pipes including fire water, Dust Suppression pipelines.

30. Walkway shall be of chequered plate construction with anti skid arrangement. Both sides of the central and side walkway shall be provided with pipe hand rail with kerb plate using pipe of ‘medium’ class as per IS: 1239 having 32mm nominal size. Handrail shall not be connected to conveyor supporting stringer.

31. Bidder to consider redundancy / stand-by for belt conveying system (1W+1S) from battery limit to bunkers for boilers feeding.

32. Angle of surcharge of coal shall be considered as 20 deg. Maximum moisture content during rainy season shall be considered for design of equipment as 20% including surface moisture.

33. The inclination of conveyors inside the tunnel shall be limited to 10 degree. The inclination of conveyors above the ground level shall be as per CEMA / IS11592. The conveyor shall be horizontal at the feed point as far as possible. In case the same is not possible, the inclination at the feed point shall be limited to 6 degree. Conveyor system shall be designed with zero leakage of coal.

34. Repose angle of coal shall be considered as 37°.

35. All the equipment shall be suitable for handling damp and sticky coal during monsoon season with moisture content of 20% and fines upto 40%.

36. The type of high speed coupling between motor and gear box shall be as follows:
(a) For motor rating up to 30 kW - Resilient type
(b) For LT motors between 30 kW and 175 kW - Traction type fluid coupling
(c) For HT motors - Actuator operated scoop type fluid coupling

If scoop type fluid coupling is applicable, fan cooling arrangement shall be provided and water cooling shall not be provided.

37. Wherever the conveyor crosses the road, a minimum clearance of 8 M shall be provided below the structure.

38. Minimum 3.15 mm thick seal plate shall be provided at all locations wherever conveyor crosses the road / building / any other facilities.

39. For over ground conveyors take-up shall not be provided in the pits. Sand pit shall be provided at the ground level.

40. In case of CFBC Boiler, bidder to consider interchangeability in crusher house to feed both the crusher from each conveyor and each crusher have provision to feed both the conveyor (1W+1S).

4.2 HOPPERS
The hoppers shall be fabricated from Carbon steel plates (min. 10 mm thickness.) conforming to IS : 2062 or equivalent / ISO and to lined with Tiscral / Sailhard (Adequate thickness minimum 12 mm) from inside not only on bottom portion but also on vertical portion for free flow of material.

4.3 FEEDERS
1. The design of the feeder shall be sturdy and robust in construction to withstand worst duty conditions and given uninterrupted flow of material. The unit shall have unbalanced motors with vibration control and variable control mechanism for controlling the rate of flow. The design shall be such that it consumes less power per ton of material handled, with less maintenance.

2. The feeder shall be able to start at full load quickly, stop smoothly and shall operate at an
extremely low noise level. With the empty tray the noise level shall be less than 85db within one meter radius of the unit.

3. Whenever the feeder shall be suspended from the top, the design of the suspension gear shall be such as to provide maximum isolation of vibrations and ensure very little transmission of spurious vibrations into surrounding structures. Turn buckles shall be provided in the suspension gear for adjusting the heights.

4. The width of the deck and height of skirts shall be sufficient to suit the duty conditions. The length of the deck shall be suitable for arresting the flow from hopper efficiently when the feeder is stopped or not in working condition.

5. The deck and skirts shall be provided with abrasion resistant liners. The through shall be suitably stiffened to avoid bending.

6. The mounting springs shall be made of high quality chrome steel.

7. No portion of the driving mechanism shall be lower than tip of the discharge point, so that sufficient clearance is available between the feeder and the belt conveyor.

8. The trough shall be inclined to give maximum output and this shall not be more than 5 degrees.

9. The feeder shall be able to deliver the coal at varying capacities (continuous variability) by varying amplitude and frequency. This variation shall be able to be controlled from the central control room with the help of a rheostat or any other contrivance.

10. All the parts of the equipment which need regular check-up / maintenance lying very close to the moving / rotating parts shall be provided with guards made of expanded metal.

11. The vibrating mechanism shall be of electro-mechanical.
   The feeder shall be able to operate round the clock and able to start in full load conditions. The feeder shall be able to operate at ambient temperatures from 4 to 50 degrees Celsius. Relative humidity of 100% and in dusty atmosphere
12. Adequate capacity feeder shall be selected by bidder at all locations. Design capacity shall be considered as min. 20% more than the rated capacity.

4.4 BUCKET ELEVATORS

1. Chain type Bucket elevator to be used wherever required.

2. The bucket elevator shall be designed for continuous duty at full load as specified under operating conditions and the various components shall conform to relevant codes.

3. Top cover shall be in pieces for easy to disassemble for the maintenance and inspection of complete drive assembly. The housing shall be provided with inspection opening at appropriate location.

4. Dust proof labyrinth metallic seal for the drive & return shaft shall be provided.

5. Bucket chain shall be of heavy duty and the chain specification with manufactures designated type/ number shall be specified in the bid.

6. Elevator shall be provided with Heavy duty positive holdback in order to prevent it from rotating backwards.

7. Hoods & safety guard shall be provided for the coupling and any other exposed rotating components. All safety switches shall be provided.

8. Adequate capacity bucket elevator shall be selected by bidder at all locations. Design capacity shall be considered as min. 20% more than the rated capacity.

4.5 VIBRATING SCREENS

1. Bidder to consider adequate capacity vibrating screen. Adequate capacity screens shall be selected by bidder. Design capacity shall be considered as minimum 10% more than the rated capacity

2. The deck of vibrating screening feeder shall have continuous solid deck section in the impact zone under direct coal fall and remaining deck shall be fitted with perforated deck
3. The solid deck section shall be provided with replaceable Tisral /Sailhard (Adequate thickness minimum 12 mm). The perforated deck shall be wear resistant and shall be rigidly fixed with main frame along the length of grizzly deck.

4. The vibrating screening feeders shall be mounted on the floor with the help of helical springs made of alloy steel. No rubber/synthetic material for the support shall be acceptable.

5. Vibrator bearings shall be grease lubricated, double spherical roller type suitable for vibrating equipment. The bearings shall be sized for minimum 8,000 hours of operation.

6. Suitable sealing arrangement shall be provided between the vibrating structure and chute work to avoid dust nuisance in the surrounding area.

7. Proper arrangement to avoid dust ingress into lubricant of eccentric shafts shall be provided.

8. Necessary arrangements shall be provided for maintaining / replacing the complete vibrator assembly.

9. In case of V- belt drive, suitable arrangement like taper bush or coupling shall be provided, to avoid loosening of sheave mounted on eccentric shaft. Dust hood shall be provided over the deck of screening feeder to avoid dust nuisance.

4.6 CRUSHER AND VIBRATION MONITORING SYSTEM (VMS)

1. Crusher shall be provided for sizing the input coal and fluxant. Crusher shall be supplied complete with accessories and subsystems.

2. Oversize raw material coming from the screen shall be transferred to the crusher. Bidder to consider adequate capacity crusher. Design capacity shall be considered as min. 10% more than the rated capacity.

3. The crusher design should be such that the crushing action is accompanied by the
minimum of attrition.

4. Uniform crushing impact shall be assured.

5. The crusher shall be capable of delivering the normal rated output even when handling damp sticky coal having maximum moisture content. No clogging or building up of material on the crushing element shall develop.

6. Temperature sensing devices shall be installed on both bearings of each of the crusher to trip the crusher in case temperature goes beyond limit.

7. The entire inside surface of crusher coming in contact with coal shall be provided with abrasion resistant steel liners.

8. The Plummer block shall be of ‘Split Type’ design and shall be fixed with minimum four numbers of high tensile steel bolt studs of adequate size complete with adequate locking device and locating arrangement. In addition, the jacking screw shall be provided for easy lifting of top part of the plummer block. The same shall be of solid base with flat machined bottom surface all around having maximum contact on the foundation plate.

9. Maximum accessibility shall be provided for routine inspection and replacement of parts. For these purposes, the doors shall be of hinge connection with effective dust sealing arrangement. Hydraulically operated top cover of crushers shall be provided for quick inspection.

10. Crusher shall be mounted on independent foundation with vibration dampring device like GERB springs and dampers.

4.7 VERTICAL ROLLER MILL

1. Vertical Roller mills shall be supplied complete with accessories and subsystems.

2. Design capacity shall be considered as min. 10% more than the rated capacity. The vertical roller mill shall be used for grinding, drying, separation and transportation.
3. Vertical roller mill shall have following features like better utilisation of grinding area, even distribution of load on the table, comparative less dynamic forces on table due to lesser mass of single moving part, variable speed mill drives and “hydraulic loading system” for maximum flexibility to vary grinding pressure.

4. Roller swing-out device for quick and easy changing of grinding components shall be provided or other facilities shall be used for quick and easy maintenance.

5. Bevel Planetary gearbox with full lubrication and gear system shall be used.

6. High efficiency dynamic classifier shall be used.

7. There shall be no metallic contact between the grinding rollers and grinding tracks.

8. Mill feed shall be sealed through rotary air lock

4.8 TRANSFER CHUTES

1. Chutes transferring Coal from one conveyor to another shall be designed in such a way that material fall height is minimum and the change in direction is achieved as smoothly as possible.

2. All the chutes shall be provided with IS: 2062 material of construction of 8 mm thickness.

3. Inspection holes / window with covers shall be provided at all convenient locations.

4. Speed of the material falling on conveyor belt in the direction of belt travel should be almost the same as that of the conveyor.

5. The angle of chutes shall be 55° as far as possible but in no case less than 50° for proper flow of material.

6. All Chutes shall be lined with material Tiscral /Sailhard (Adequate thickness minimum 12 mm).
4.9 BUNKERS

1. The bunkers shall be of round shape and fabricated from Carbon steel plates (min. 10 mm thickness) conforming to IS : 2062 or equivalent / ISO and to lined with Tiscral /Sailhard (Adequate thickness minimum 12 mm) from inside not only on bottom conical portion but also on vertical portion for free flow of material.

2. Bunkers shall be provided with load cells, vibrators/poking hole, ultrasonic level indicator etc. The angle of conical portion of bunkers shall be kept as 55° with the horizontal.

3. Feeding to bunkers shall be automatic with the help of series of conveyors system.

4.10 FLAP GATES

1. The motor operated 2 position flap gates shall be provided in transfer chutes as specified and shall be complete with electrically operated actuators. The gates shall be of robust construction and suitable for trouble free operation.

2. The motor rating for the actuator shall be so selected as to provide sufficient thrust for operation of the flap gates against the moving weight of coal and/or flap gate. The flap gate travel shall be 60 deg. The motor shall be completely dust proof.

3. Lever arm shall be provided between actuator and flap gate shaft for obtaining required thrust.

4. The actuators shall be capable of preventing any over travel. These shall be placed internal to the drive unit and shall be completely dust-proof. The limit switches shall be capable of adjustments to vary the total length of travel of the gates.

5. Provision for alternative manual operation shall also be made using de-clutch able hand wheel. The diameter of hand wheel shall be selected considering convenient force to be applied by a single operator. However, minimum diameter of hand wheel shall be 500 mm. Limit switch for safety of person operating the hand wheel shall be provided. Manual effort required to operation the flap gate shall not exceed 25 kg.
4.11 RACK & PINION GATES / ROD GATE

1. Rotary actuator operated rack and pinion gates shall be provided at various locations as required. The gate shall be mounted such that coal load does not act vertically on gate.

2. Suitable manually operated rod gates shall be provided over rack and pinion gates for their easy operation and maintenance. The rack and pinion gate shall be guided properly and suitable rollers with bearings sealed for life and dust proof shall be provided.

3. The rack and pinion gates shall be of carbon steel construction with liner plate of Tiscral /Sailhard (Adequate thickness minimum 12 mm). The gates shall be operated by means of double rack and pinion. The material for rack & pinion wheel shall be cast steel and shaft shall be EN.-8.

4. Provision for alternative manual operation of motorized rack and pinion gates shall also be made. Limit switch for safety of person operating the hand wheel shall be provided.

5. Manual effort required to operate the rack and pinion gate shall not exceed 25 kg.

4.12 BELT SCALE

1. Belt weigh scale for measurement of coal flow rate and quantity shall be provided at specified locations. System shall be complete with flow rate indicator, totaliser, control panel etc.

2. The weigh scale shall be automatic and electronic type. It should be designed for continuous automatic weighing, metering and printing of coal flow.

3. Each belt weigh scale shall comprise of a belt weigh scale platform with minimum 4 nos. weighing idlers. It shall have unitized construction for ease of installation and shall be fully floating type (without pivot points). Minimum 4 nos. hermetically sealed load cells of precision strain gauge type shall be applied in tension to support the weigh bridge. The load cells shall have 100% overload protection and shall be structurally safe upto to 250% of rated belt scale capacity.
4. Belt scale shall be electronic microprocessor based with its program stored in non-volatile memory.

5. It shall be provided with self-diagnostic features for trouble shooting of the entire belt scale system. Fully automatic zero and span calibration facility shall be provided.

6. The electronic systems offered by the Contractor shall include all signal conditioning, power amplifiers and printed circuits etc. The printed circuits shall be encapsulated against dust and moisture.

7. The flow rate indicator shall have minimum 4 digits. The flow totalizer should have 8 digits display scale with reset facility.

Complete belt scale system shall be suitable for 50°C ambient temperature and 100% relative humidity. It shall be suitable for outdoor installation in a dusty area. The electronic circuit enclosure, sensors housing shall be dust and watertight.

8. Accuracy of belt weigh scale shall be ± 0.5% of actual weighment.

**4.13 INLINE MAGNETIC SEPARATOR / SUSPENDED MAGNET**

Inline Magnetic Separators shall be provided for continuous and automatic extraction and discharge of tramp magnetic pieces from coal being discharged from conveyors as specified. The sets shall be complete in all respects with drives, magnets, inline belts, hoppers, chutes, tramp-iron boxes and all electrical ancillaries like control panels etc. Suspended Magnetic Separator shall be provided for picking up tramp magnetic pieces buried under coal from moving coal over Conveyor as specified.

**4.14 TRAVELLING TRIPPER UNIT / SHUTTLE CONVEYOR & BUNKER SEALING ARRANGEMENT**

1. Rail mounted movable travelling Tripper / shuttle conveyor shall be provided to feed coal to overhead bunkers of Boilers.

2. Mobile Trippers on bunker conveyors along with belt sealing arrangement shall be furnished and erected complete with rails, including necessary supporting structures,
approach/maintenance platforms with ladders and hand railings, trailing cables, all electrical including machine mounted local control panel & control panel on one end of bunker, location of which shall be decided during detail engineering.

3. The Mobile tripper conveyors shall be motor driven type. It shall consist of structures, supports, walkways, rails, belt scrapper with adjustable rubber strip, rubber lagged head and bend pulleys complete with shaft bearings, chutes, stops, limit switches, brakes etc. The rating of tripper travel motor shall be adequate to move the tripper smoothly either in same or opposite direction to belt direction under fully loaded conditions. Minimum two drive axles shall be provided for tripper travel. Arrangement shall be provided at the starting point of the tripper to avoid folding of belt.

4. Supply of adequate length of rails to cover the runway length for the motor driven tripper shall be included. Suitable belt hold down guide pulley shall be provided over the concave curve of belt over tripper.

5. The travelling trippers shall be provided with fail safe A.C. thruster operated brake of totally enclosed type which shall engage as soon as tripper travel motor stops. A.C. thruster operated rail clamps along with manual Rail clamps on both side of the tripper shall also be provided.

6. Monorail & electric hoist shall be provided for lifting conveyor drum to floors. Monorail all along the tripper travel length to facilitate maintenance of tripper shall be provided.

7. Suitable dust cover shall be provided over tripper head pulley. Serrated rubber seal shall be provided at open side to prevent dust nuisance. Suitable dust tight access doors shall be provided. Spring loaded scraper type belt cleaner shall be provided below the tripper head pulley for cleaning the carrying side of the belt.

8. The tripper shall run on rails with double flanged wheels. Rails for tripper travel shall be mounted on supporting structure of respective conveyors.

9. Suitable system having encoders for monitoring position of tripper in DCS shall be provided. In addition, travel end limit switches and end stops shall also be provided.
10. Suitable access platform of chequered plate with ladders, hand railing and walkways on both sides shall be provided for access/maintenance of equipment on tripper. In addition, crossover platform shall be provided with tripper so that operator can cross the belt through the same.

11. Suitable rail cleaners shall be provided on leading and trailing edge of tripper for either track.

12. In case of bunker feeding, the tripper shall have provision for dropping coal from conveyor onto one side of tripper to the bunker or back to the conveyor for the purpose of skipping intermediate bunkers. Complete Bunker Sealing arrangement shall be provided over the bunkers to prevent dust emission into tripper bay.

5.0 DUST EXTRACTION SYSTEM
Dust control system shall be of dry / wet / extraction type and as well as dust suppression type to suit at the application point.

The Contractor shall require providing suitable dust control system at suitable location for coal screening, crushing, coal crushing and feeding system etc.

The dust control system to be furnished under this specification is required for control of fugitive dust emissions from dust generation points such as transfer points, feeders, crushers etc. Dust control is achieved by dust suppression/extraction system.

Dust control system which shall not allow a dust concentration in the ambient air inside the buildings more than acceptable limits as per the approved guidelines or any internationally recognized hygienic Standards/Codes.

Dust extraction system shall include but not limited to following- hoods, duct/ pipes (duct thickness shall be considered as per calculation but min. 5mm thickness), centrifugal fans/blowers, motors, rotary valve etc.

6.0 ASH HANDLING SYSTEM
6.1 SCOPE
The scope shall include complete ash handling system comprising bed ash handling system, fly ash handling system, bed ash storage silo, fly ash storage silo and equipment below silo. The ash handling system and equipment to be supplied shall be as per the system description and flow diagram enclosed. The ash handling system shall be complete in all respects with all mechanical, civil, structural, electrical and instrumentation.

The extent of supply under the contract includes all items shown in the drawings, notwithstanding the fact that such items may have been omitted from the specifications or schedules. Similarly the extent of supply also includes all items mentioned in the specification and/or schedule notwithstanding the fact that such items may have been omitted in the drawings.

6.2 SYSTEM DESCRIPTION

6.2.1 Bed ash handling system

Bed ash formed due to the combustion of coal in the boiler. After that ash collected in various bed ash cooler outlet, shall be automatically and sequentially extracted. Below each bed ash cooler outlet, adequately sized water-jacketed surge hopper shall be provided to reduce the ash temperature below 200 degree Celsius. Ash collected in the surge hopper shall be conveyed through a dense phase pneumatic conveying system up to bed ash silo for storage and further disposal.

The ash removal system below each ash hopper shall consist of MS adaptor, knife gate valve, metallic expansion joint, and ash intake valve and ash vessel. The ash vessel receives ash from respective hoppers and conveys it to the ash conveying pipeline provided below each of the ash vessels. Required compressed air shall be supplied to ash vessel for conveying ash from the ash vessels to the ash silo. The ash conveying air collected in the ash silo shall be vented to atmosphere through bag filter/vent filter mounted on silo top.

Occasional lumping of ash due to clinker formation should be considered in bed ash handling system and hence the surge hopper shall be provided with lump separator (if applicable).

Dry bed ash shall be collected in RCC silo having adequate storage capacity (24 hrs of ash generation) from where dry bed ash shall be unloaded into open/closed trucks for ash utilization facilities.
Contractor to ensure zero leakage of ash from bed while designing bed ash handling system.

6.2.2 Fly Ash Handling System

The fly ash collected at the air preheater hoppers, economiser hoppers, ESP hoppers and stack hopper any other fly ash hopper if applicable shall be gravity fed into individual transmitter vessels provided below each hopper. On initiation of dry fly ash collection system, the inlet valve shall open and allow the fly ash to be fed into the transmitter vessel for predetermined time after which the inlet valve shall close. Afterwards, the compressed air shall be allowed to flow into the transmitter vessel by opening the air inlet valve. Once the desired conveying pressure is reached inside the vessel, the fly ash shall be conveyed to the fly ash storage silo through transport piping. The conveying air shall be vented through the bag filters mounted on top of the silo in order to limit the dust concentration in the vented air below 30 mg./N.cu.m. The hoppers if connected to a common conveying line along the gas path, they shall be cleared one after another. The clearance from any hopper shall continue cycle after cycle till ash in the hopper reaches to low level. Removal of fly ash from any particular hopper shall be initiated whenever the level of ash in that hopper reaches predetermined level. This level is fixed in such a way that the volume of ash collected will be adequate for conveying in one cycle. Thus in this system, the fly ash hoppers are always kept empty. Therefore the removal and conveying of fly ash to the fly ash silo shall be done in cyclic manner on a continuous basis. The dry fly ash collected in storage FA silo will be disposed into the open trucks/closed container through conditioner/retractable chute in dry form for further disposal to ash disposal area or for utilisation in nearby cement plants/brick plants by others.

The total ash removal system shall be divided into parallel paths. There shall be separate line (Path) connection for 1st field ESP hopper and 2nd field hopper and third field and common line (path) connection for other field provided for proposed ESP. For ECO and APH hopper there shall be common line connection and for cyclone shall be separate line connection. Provision of conveying cyclone ash shall be provided in fly ash silo. Shifting of ash clearance cycle from one hopper to the next shall be automatic and based on level.

Normally the fly ash conveying system shall operate continuously but with time gaps between cycles. The vessel sizes are selected in such a way as to get specified capacity. The fly ash
removal system shall be designed on a continuous basis with 20 cycles per hour and during emergency with 40 cycles per hour (i.e., ash collected in 8 hours time shall be evacuated in 4 hrs time). The level probe shall be provided in each hopper in such a way that the ash collected in the hopper shall be equal to the volume of the ash transmitter vessel. This level probe shall initiate the ash evacuation cycle from any hopper. The timer based operation shall back up in case the level probe fails to initiate the ash evacuation cycle. There shall be one manually operated isolating valve (knife gate type) below each fly ash hopper which shall be used during maintenance of the ash transmitter vessel.

Two (2) Screw compressors, one standby, one operating for the unit during normal and rapid evacuation operation shall be provided to meet the conveying air requirements of fly ash handling system of Unit.

6.3 Storage Silos and Disposal of ash from silos

6.3.1 Bed Ash Storage Silo
There shall be one bed ash storage silo for all boilers. The silo shall be sized to store bed ash generated in a day from the proposed unit based on firing of worst coal at BMCR condition. Silos shall be of RCC construction. Silo shall be of flat bottom design. Silo area shall be paved and drain shall be provided at the periphery of the paved area.

Silo shall have four (4) Nos. of outlet connections in which 3 nos. of outlets are with rotary feeder for unloading of ash in different form as mentioned below.

a) One opening for unloading of ash in dry form to closed tank carriers through Telescopic chute.

b) One opening for unloading of ash through ash conditioner into open truck.

c) One opening for ash transportation directly to Ash/slag pond in slurry form (by others).

d) One opening for blind flange with chain wheel operated for future use.

6.3.2 Fly Ash storage silo
There shall be one fly ash silo for all the boilers. The silo shall be sized to store fly ash generated in a day from the unit based on firing of worst coal at BMCR condition. Silos shall be of RCC construction. Silo shall be of flat bottom design. Silo area shall be paved and drain shall be provided at the periphery of the paved area.
Fly ash silo shall be provided with four (4) outlets.

a) One outlet shall be used to load ash into the open trucks (open trucks by others) in conditioned form for further disposal by others into the disposal area. For this purpose a rotary feeder and ash conditioner shall be provided.

b) The other outlet shall be used to dispose ash in closed containers (by others) for utilisation. This outlet shall be provided with rotary feeder and a motor operated retractable chute.

c) One opening for ash transportation directly to Ash/slag pond in slurry form (by others).

d) One opening for blind flange with chain wheel operated for future use.

The silo shall be sized to store fly ash generated in a day (24hrs) from the proposed unit based on firing of worst coal at BMCR condition.

Note- Bidder to consider instrument system including additional bag/vent filter for flyash transfer of Coal gasification plant in both Flyash silo and Bed Ash silo.

6.4 SYSTEM CAPACITY

6.4.1 Bed Ash Handling System

The minimum rate of generation of bed ash shall be considered as 20 % of total ash generated from worst coal at BMCR condition. The rated capacity of the bed ash conveying shall be based on 150 % margin over bed ash generation rate based on worst coal at BMCR condition.

6.4.2 Fly Ash Handling System

The rate of generation of fly ash shall be considered as 90 % of total ash generated from the worst coal at BMCR condition. Normally the fly ash conveying system shall operate continuously with time gaps between cycles. However, the capacity of fly ash handling system shall be designed to clear the ash collected in 8 hours in about 4 hours time considering worst coal. Accordingly all the equipment shall be sized.

6.5 DESIGN & OTHER GENERAL REQUIREMENTS

6.5.1 Bulk Density of Ash

(a) For Volumetric Calculation

<table>
<thead>
<tr>
<th>Ash Type</th>
<th>Bulk Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed ash and Eco ash</td>
<td>0.65 T/m³</td>
</tr>
<tr>
<td>Cyclone ash, ESP ash and air preheater</td>
<td>0.75 T/m³</td>
</tr>
</tbody>
</table>
(b) For Structural Load Calculation

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Density (T/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed ash and Eco ash</td>
<td>1.6</td>
</tr>
<tr>
<td>Cyclone ash, ESP Ash and air preheater ash</td>
<td>1.6</td>
</tr>
</tbody>
</table>

For selection of pneumatic handling system: 500-800 kg/cu.m

Type of material: Abrasive

6.5.2 The pneumatic handling system for fly ash shall be of dense phase and the velocity of air ash mixture shall not exceed 10 m/s.

6.5.3 All the bends in the pneumatic handling system shall be provided with wear back of either Ni-hard or stone box type.

6.5.4 High and low level probes shall be provided in each ash hopper for measuring the evacuation rate during PG test.

6.5.5 In case vent valves are provided for the transmitter vessels this vent connection shall be provided above the highest ash level in the hopper.

6.5.6 The movements of the ash hoppers, due to the expansion shall be considered and the Contractor shall include suitable expansion joints as necessary in the ash pipe lines. The expansion joints shall be of stainless steel construction.

6.5.7 The radius of 90 deg. bends shall be minimum 5 times the pipe diameter.

6.5.8 Fluidising pads in fly ash silos, ESP hoppers and other vessels shall be preferably of woven stainless steel and should withstand temperature upto 200°C. Platforms shall be provided for fluidising pads and ESP ash level indicators.

6.5.9 Ash silos shall be provided with access ladder inside the silos and external staircase from ground level to different platforms.

6.5.10 The material of construction of all parts of rotary feeder coming in contact with ash shall be of alloy CI as per IS-4771 type 1a with minimum hardness of 340 BHN.
6.5.11 The motor rating for all the equipment shall have a margin of 10% over the BKW. The service factor for selection of gearboxes, resilient couplings, flexible couplings, brakes etc., shall be 1.5 minimum on the motor rating.

6.5.12 The type of high speed coupling between motor and gearbox shall be as follows:
   (a) For motor rating upto 30 kW : Resilient type
   (b) For LT motors of above 30 kW rating : Traction type fluid coupling

6.5.13 The emission level at the outlet of the bag filter shall be limited to 30 mg / Nm3.

6.5.14 Ash Handling system shall be fully automated.

6.5.15 All Equipment shall be designed for continuous duty of 24 hours per day.

6.6 Dust Conditioning Water Pumps at Terminal Silo Area
Two (1W+1S/B) dust conditioning water pumps shall be provided by bidder to moist dry ash in order to avoid nuisance during open truck unloading. Ash water sump, from which dust conditioning water pumps will take its input, shall have minimum 30-minute effective storage capacity.

6.7 Drain Pumps at Terminal Silo Area
Two (1W+1 S/B) drain pump shall be provided by Bidder at terminal silo area. Drain pit shall connect the peripheral drain of silo-paved area.

6.8 Conveying Air Compressor
Bank of Conveying Air Compressors shall be provided common for all the Units. The conveying air compressor shall be Oil injected Screw type. Necessary conveying air pipe work shall be MS ERW.

6.9 Silo Fluidising Blower and Heater
Two numbers Silo fluidising blower (1W+1 S/B) and two numbers Silo fluidising blower heater (1W+1 S/B) shall be provided to heat air discharged through Silo fluidizing blower. Each Silo fluidizing blower discharge shall be connected with one heater and lines shall be interconnected so that any heater can be utilized by any blower.
### 6.10 Equipment Technical Sheet

#### 6.10.1 Water cooled Surge Hopper

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Items</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>No. required</td>
<td>To suit boiler ash collection hoppers</td>
</tr>
<tr>
<td>2.</td>
<td>Type of Hopper</td>
<td>Water cooled surge hopper</td>
</tr>
<tr>
<td>3.</td>
<td>Number of outlets</td>
<td>one operational and one for manual bypass</td>
</tr>
<tr>
<td>4.</td>
<td>Location</td>
<td>bed ash cooler, cyclone, APH &amp; ECO ash hopper</td>
</tr>
<tr>
<td>5.</td>
<td>Required storage capacity of ash in hopper</td>
<td>For bed ash Minimum two conveying cycle For cyclone, APH &amp; ECO ash 8 Hrs of maximum ash generation</td>
</tr>
<tr>
<td>6.</td>
<td>Minimum thickness of surge hopper plate</td>
<td>6 mm thick M.S. to IS: 2062 with 10 mm thick abrasion resistant Alloy C.I. liners of 300-350BHN hardness at sloping surfaces and outlet area.</td>
</tr>
<tr>
<td>7.</td>
<td>Cooling water header for surge hopper</td>
<td>IS 1239</td>
</tr>
<tr>
<td>8.</td>
<td>Surge hopper cooling arrangement</td>
<td>Yes</td>
</tr>
<tr>
<td>9.</td>
<td>Manual by pass</td>
<td>Yes</td>
</tr>
<tr>
<td>10.</td>
<td>Pneumatic / Manually operated knife gate valve at the outlet of surge hopper</td>
<td>Yes</td>
</tr>
<tr>
<td>11.</td>
<td>Blow tank/Master vessel along with dome valve, below each surge hopper.</td>
<td>Yes</td>
</tr>
<tr>
<td>12.</td>
<td>Level probe</td>
<td>Yes</td>
</tr>
</tbody>
</table>

#### 6.10.2 PNEUMATIC CONVEYING SYSTEM FOR ASH HANDLING
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Items</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Ash Handling System Capacity (TPH)</td>
<td>Contractor to indicate</td>
</tr>
<tr>
<td>2.</td>
<td>Number of Hrs of Operation</td>
<td>Continuous/ Emergency - 8 hrs in 4 hours</td>
</tr>
<tr>
<td>3.</td>
<td>Material to be Handled</td>
<td>Bed Ash and Flyash</td>
</tr>
<tr>
<td>4.</td>
<td>Fly Ash Transmitter Type</td>
<td>Suitable for pressure type pneumatic conveying</td>
</tr>
<tr>
<td>5.</td>
<td>MOC of Transmitter Vessel</td>
<td>Cast Iron/Fabricated Out Of Ms Plate Of Min. 10 Thk.</td>
</tr>
<tr>
<td>6.</td>
<td>Construction of Vessel</td>
<td>As Per ASME Code For Unfired Pressure Vessel Or Is-2825</td>
</tr>
<tr>
<td>7.</td>
<td>Level probe for fly ash hopper</td>
<td>Yes</td>
</tr>
<tr>
<td>8.</td>
<td>Level probes for fly ash transmitters</td>
<td>Yes (if system requires)</td>
</tr>
<tr>
<td>9.</td>
<td>Timers as back up for level probes</td>
<td>Yes</td>
</tr>
<tr>
<td>10.</td>
<td>Safety valve on vessel</td>
<td>Yes</td>
</tr>
<tr>
<td>11.</td>
<td>Control panel</td>
<td>Yes</td>
</tr>
<tr>
<td>12.</td>
<td>Testing of the fabricated</td>
<td>As per ASME Section VIII or IS 2825 transmitter vessels</td>
</tr>
<tr>
<td>13.</td>
<td>Fly Ash Valves/ Knife Gate Valves body</td>
<td>Alloy CI 350 BHN for Branch Isolation and CI for Hopper Isolation</td>
</tr>
<tr>
<td>14.</td>
<td>Slide plate</td>
<td>SS 304 Edge Stellited for Branch Isolation and SS-304 to Min. 1 mm Thickness for Hopper Isolation</td>
</tr>
<tr>
<td>15.</td>
<td>Valve seat</td>
<td>Alloy CI 350 BHN for Branch Isolation and CI for Hopper Isolation</td>
</tr>
<tr>
<td>16.</td>
<td>Valve shaft</td>
<td>SS - 316</td>
</tr>
<tr>
<td>17.</td>
<td>Provision of operating handle for manual operation and position indicator</td>
<td>Yes</td>
</tr>
<tr>
<td>18.</td>
<td>Fly Ash Inlet Valves Type</td>
<td>Dome Valves / Swing Disc Valves / Knife Gate Valve</td>
</tr>
<tr>
<td>19.</td>
<td>Fly Ash Inlet Valves Location</td>
<td>At inlet to Ash Transmitter</td>
</tr>
</tbody>
</table>
## 6.10.3 AIR-ASH TRANSPORT PIPING AND FITTINGS

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Items</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Piping</td>
<td>ERW MS heavy duty (for average carrying velocity of 10 M / SEC.). for higher velocity of air ash mixture, contractor should increase the thickness of pipe suitably.</td>
</tr>
<tr>
<td>2.</td>
<td>Fittings</td>
<td>Ni-Cr Alloy cast iron as per IS:4771, TYPE 1a with minimum 4.5% Ni and Hardness of 550 BHN</td>
</tr>
<tr>
<td>3.</td>
<td>Type of Wear Back for Fittings</td>
<td>Integral</td>
</tr>
<tr>
<td>4.</td>
<td>Min. Thickness of Wearback</td>
<td>Twice the Pipe Wall Thickness</td>
</tr>
<tr>
<td>5.</td>
<td>Radius of 90o bends</td>
<td>Minimum 5 Times Pipe Diameter</td>
</tr>
</tbody>
</table>

## 6.10.4 AIR PIPING

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Items</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Conveying Air Piping Material – Piping &amp; Fittings</td>
<td>GI &amp; Forged Steel</td>
</tr>
<tr>
<td>2.</td>
<td>Velocity in air piping</td>
<td>10 M/S (Average)</td>
</tr>
</tbody>
</table>

## 6.10.5 BAG FILTER

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Items</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Location</td>
<td>At the air outlet of and fly ash silo.</td>
</tr>
<tr>
<td>2.</td>
<td>Type</td>
<td>Reverse Pulse Jet Type Vent filter at silo top</td>
</tr>
<tr>
<td>3.</td>
<td>Material of bags</td>
<td>Polyester Needle Felt Of Antistatic Type</td>
</tr>
</tbody>
</table>
### 6.10.6 EXPANSION JOINTS

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Items</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Type of Expansion Joints</td>
<td>Stainless Steel Expansion Joints</td>
</tr>
</tbody>
</table>

### 6.10.7 FLY ASH SILO AND BED ASH SILO

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Items</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Material of construction</td>
<td>RCC fly ash silo and MS silo for bed ash</td>
</tr>
<tr>
<td>2.</td>
<td>Type of Level Measurement and indicator</td>
<td>Continuous/RF type</td>
</tr>
<tr>
<td>3.</td>
<td>Liners for bed ash silo</td>
<td>Bed ash silo shall be lined with 5 mm thick SS 409M on sloping surface and 50 mm thk guniting on vertical portion</td>
</tr>
</tbody>
</table>

### 6.10.8 CONTINUOUS DUST CONDITIONER, UNLOADER AND FEEDER

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Items</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Location</td>
<td>Below FA silo</td>
</tr>
<tr>
<td>2.</td>
<td>Type</td>
<td>Paddle Type</td>
</tr>
<tr>
<td>3.</td>
<td>Maximum moisture content</td>
<td>15%</td>
</tr>
<tr>
<td>4.</td>
<td>Type of feeder above unloader</td>
<td>Air Lock Type Rotary Feeder and capacity - 80 / 100 TPH (Rated / Design)</td>
</tr>
<tr>
<td>5.</td>
<td>Trough MOC</td>
<td>M.S. 6 Mm Thick With SS 410 5mm Thick Liners.</td>
</tr>
<tr>
<td>6.</td>
<td>Top cover plate MOC</td>
<td>M.S. 6 mm thick</td>
</tr>
<tr>
<td>7.</td>
<td>Shaft MOC</td>
<td>SS 316</td>
</tr>
<tr>
<td>8.</td>
<td>Paddles MOC</td>
<td>SS 304 - Welded To Shaft</td>
</tr>
<tr>
<td>9.</td>
<td>Spray nozzles MOC</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>10.</td>
<td>Type of gate at silo outlet</td>
<td>Cylinder operated Knife Gate Valve</td>
</tr>
<tr>
<td>11.</td>
<td>Unloading Spout Capacity</td>
<td>80 / 100 TPH (Rated / Design)</td>
</tr>
</tbody>
</table>
7.0 ACCESS TO MACHINERY

Special attention shall be given in providing adequate access to all machinery for safe operation / maintenance and cleaning purpose.

Provision shall be made for lifting out and replacing equipments such as motors, gearboxes, and other heavy machinery with the help of electric hoist. Capacity of the hoist would be based on the weight of the heaviest part to be lifted.

8.0 ELECTRICAL SYSTEM

Bidder to consider all Electrical systems and items for material Handling Portion as per Electrical Design Philosophy / Specification.

9.0 CONTROL AND INSTRUMENTATION SYSTEM

Bidder to consider all instrumentation systems and items for material handling portion as per Instrumentation Design Philosophy / Specification.

10.0 CIVIL WORK

Bidder to consider all Civil & structural work for material handling portion as per Civil Design Philosophy / Specification.
SECTION VI – 5.3.5

DESIGN PHILOSOPHY – FIRE FIGHTING SYSTEM

PLANT: STEAM GENERATION PLANT

PROJECT: INTEGRATED COAL BASED FERTILISER COMPLEX AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA)
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<td>Scope</td>
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<tr>
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<td>Fire water system.</td>
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<td>9.0</td>
<td>SAFETY EQUIPMENTS</td>
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<td>10.0</td>
<td>SAFETY IN SYSTEM DESIGN</td>
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<td>Annexure-1</td>
<td>Detection, Actuation, Alarm and Communication System</td>
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LIST OF ATTACHMENTS

<table>
<thead>
<tr>
<th>ATTACHMENT NUMBER</th>
<th>DESCRIPTION</th>
<th>NUMBER OF SHEETS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1.0 PURPOSE

The purpose of this document is to establish the design basis of the complete fire fighting system.

2.0 DEFINITIONS

Owner - Talcher Fertilizers Ltd. (TFL)
LSTK- Lump Sum Turn Key Contractor
CCE - Chief Controller of Explosives
NFPA - National Fire Protection Association
IS - Indian Standards
TAC- Tariff Advisory Committee

3.0 SCOPE

3.1 This specification covers design basis and execution requirements for fire protection system as per statutory regulations NFPA codes. The design and construction of the fire detection and protection equipment shall be of internationally accepted standards and in compliance with the regulations of the Tariff Advisory Committee (TAC) and other relevant statutory requirements for steam generation plant of TFL. Any other Standard which are not mentioned in the technical specification but are found necessary to meet the requirement of TAC and also for safe and sound operation of the plant are to be included at no extra cost to the Owner.

3.2 The LSTK CONTRACTOR shall design, supply and erect complete fire fighting network / system inside and around Steam Generation Plant.

3.3 The Bidder shall confirm that the fire fighting system is complete with all facilities whether specified in this specification or not.

3.4 A comprehensive fire detection and alarm system and fire protection system shall be designed for the whole of the proposed steam generation plant to provide a high degree of protection for plant, equipment and buildings and employees. Interfacing with other systems (e.g. fuel and air handling plants, ventilation systems, etc.) will be required.

3.5 Taping/s with the fire water mains provided at plant battery limit (adjacent to the proposed plant location) shall be provided as per requirement. The same (tie-in location/s) shall be decided during the detail engineering.

3.6 The CONTRACTOR'S design and engineering activities listed in this specification are the minimum requirements to be complied with preparation of detailed design basis, specifications, standards and list of codes for each system based on guidelines given in subsequent clauses of scope of work.

3.7 The term 'Fire Fighting System' referred here generally covers various equipments and facilities being provided for controlling fires. These include facilities such as fire water network accessories and fire detection & control system, fire water piping network together with hydrants, monitors, detectors/alarm, various kinds of portable fire extinguishers like Dry Chemical Powder type, etc., as well as sand and water buckets and sign boards.

3.8 The Fire Fighting System shall be designed to provide adequate facilities for extinguishing any fire in the entire area of Steam Generation Plant and associated facilities of the proposed
Scope of work. The system shall be designed and installed as per TAC / NFPA/ API/ IS standards and also as per latest applicable standards/ codes. The system shall be complete in all respects essential for proper installation operation and maintenance, irrespective of whether such systems are specifically mentioned in this specification or not.

3.9 Hydraulic analysis of fire water ring main network including line size, flow and pressure at various section of the system shall be submitted for Owner/Consultant’s approval.

3.10 The detail design shall take into consideration of all stipulations, practices followed by Statutory Regulations/Authorities for all types of jobs of this package.

3.11 Preparation of PFD/ P&ID’s and equipment data sheets. Preparation of material take-off, material requisitions and purchase requisition of bought out items. Design calculations for the respective fire protection system. Installation drawings and documents. Operating maintenance and spare parts manuals wherever applicable.

3.12 Taking approval from statutory authorities.

3.13 The following latest Codes and Standards shall be followed.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Stds No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NFPA-1</td>
<td>Uniform Fire Prevention Code</td>
</tr>
<tr>
<td>2</td>
<td>NFPA-10</td>
<td>Portable Fire Extinguishers</td>
</tr>
<tr>
<td>3</td>
<td>NFPA-11</td>
<td>Low Expansion Foam and Combined agent Systems</td>
</tr>
<tr>
<td>4</td>
<td>NFPA-12</td>
<td>Carbon dioxide extinguishing Systems</td>
</tr>
<tr>
<td>5</td>
<td>NFPA-12A</td>
<td>Halon 1301 Fire Extinguishing Systems</td>
</tr>
<tr>
<td>6</td>
<td>NFPA-13</td>
<td>Installation of Sprinkler Systems</td>
</tr>
<tr>
<td>7</td>
<td>NFPA-14</td>
<td>Installation of Stand Pipe &amp; Hose Systems</td>
</tr>
<tr>
<td>8</td>
<td>NFPA-15</td>
<td>Water Spray Fixed System for Fire Protection</td>
</tr>
<tr>
<td>9</td>
<td>NFPA-16</td>
<td>Installation of deluge foam-water sprinkler and foam water spray systems.</td>
</tr>
<tr>
<td>10</td>
<td>NFPA-17</td>
<td>Dry chemical extinguishing systems.</td>
</tr>
<tr>
<td>11</td>
<td>NFPA-17A</td>
<td>Wet Chemical Extinguishing Systems</td>
</tr>
<tr>
<td>12</td>
<td>NFPA-70</td>
<td>National electric code.</td>
</tr>
<tr>
<td>13</td>
<td>NFPA-72</td>
<td>National Fire Alarm Code</td>
</tr>
<tr>
<td>14</td>
<td>NFPA-77</td>
<td>Recommended Practice on Static Elect.</td>
</tr>
<tr>
<td>15</td>
<td>NFPA-2001</td>
<td>Clean Agent Fire Extinguishing Systems</td>
</tr>
<tr>
<td>16</td>
<td>PII-5.3.1</td>
<td>Design Philosophy Piping</td>
</tr>
</tbody>
</table>

Also LSTK Contractor shall follow the following manuals/ references for fire fighting system:

- Rules of Water Spray System
- Rules for Automatic Sprinkler Installations

3.14 All equipment in the entire fire protection & detection system shall have the approval from one of the followings:

a) UL of USA
b) LPCB-UK
c) BIS-India
d) FM-USA
However, the design and installation of complete system and requirement shall be approved by statutory authorities.

### 4.0 SPECIFICATION FOR FIRE PROTECTION SYSTEM

#### 4.1 System Requirement

The fire protection System is required to ensure protection of the facility in order to combat an outbreak of fire so as to reduce damage and consequential losses. The fire Protection system includes fire detection, containment and suppression system. The Proposed fire protection system will be designed to provide adequate safety measures in the areas susceptible to fire in the steam generation plant in compliance with the recommendations of the Tariff Advisory Committee (TAC). The Entire Fire fighting system will have a centralised panel housing the required Electrical, mimic of the system and will be hard wired to the centralized DCS to show the Mimic and provide alarms.

The Indicative Area wise requirement of fire detection and protection system will be as given below.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Area</th>
<th>Type of detection</th>
<th>Type of Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Transformer above 5 MVA in Transformer yard.</td>
<td>Quartzoid Bulb detector</td>
<td>Automatic High Velocity Water Spray System.</td>
</tr>
<tr>
<td>2</td>
<td>Cable Vault in Electrical control Building</td>
<td>Ionisation type smoke Detector.</td>
<td>Portable Fire Extinguisher.</td>
</tr>
<tr>
<td>3</td>
<td>Control Room</td>
<td>Addressable smoke detector of Ionisation &amp; Photoelectric type.</td>
<td>Clean Agent System.</td>
</tr>
<tr>
<td>4</td>
<td>Switchgear room, MCC Rooms in Control / Electrical Building</td>
<td>Addressable smoke detector of Ionisation &amp; Photoelectric type.</td>
<td>Clean Agent System.</td>
</tr>
<tr>
<td>5</td>
<td>Battery/UPS Room</td>
<td>Suitable Smoke/Heat/H2 detector with alarm in control room</td>
<td>Clean Agent System.</td>
</tr>
<tr>
<td>7</td>
<td>Sub Station</td>
<td>Addressable smoke detector of Ionisation &amp; Photoelectric type.</td>
<td>Spray system. (Carbon dioxide gas flooding fire extinguishing system for Electrical panels at substations)</td>
</tr>
</tbody>
</table>

Apart from the above station building, transformer yard, boiler area, pumps, compressor and fuel handling plant will be protected with hydrant system.

Following types of Fire Protection system shall be provided.

i) Hydrant System.

iii) Automatic Fixed Foam system for Fuel Oil storage Tanks.
iv) Automatic inert Gas system.
v) Portable and Mobile Fire Extinguishers.
vi) Automatic CO2 Fire Fighting system.
vii) Jets/portal curtains/DCP/special DCP etc.

4.1.1 Category under TAC

The steam generation plant falls under “ordinary” hazard category. Boiler house building, control room, switch gear room in control and other electrical building, battery room, pumps and other area will be provided with only portable fire extinguishers.

5.0 FIRE WATER DISTRIBUTION SYSTEM

5.1 General

i) Fire water ring header shall be extended to all the process plants and storage areas. Material for fire water piping shall be outer wrapping/coating carbon steel with cathodic protection for underground piping and carbon steel for aboveground piping.

ii) Underground fire hydrant ring main facility, with strategically placed hydrant connections, shall be provided to suit the site/plant/building configuration.

iii) Indoors hydrants for plant and non-plant buildings shall be provided as required.

iv) Risers shall be provided for internal protection to boiler galleries at various levels. All hose connection points shall be fitted with landing type valves with instantaneous female connections. Top landing valves shall terminate at the boiler house roof levels.

v) Hydrants shall be spaced at 30 m for high hazard occupancies, at 45 m for moderate hazard occupancies and at 60 m for low hazard occupancies.

vi) Fixed Water Spray Systems (Sprinkler / High Velocity Spray Water / Medium Velocity Spray Water) shall also be considered for establishing the conformity of fire protection system.

vii) For process units, external ring header with hydrants and an internal distribution with monitors and hose reels shall be installed.

viii) Along the network, a number of block valves shall be located in such a way that the various areas of the plant can be fed with fire water even during maintenance operations on part of the fire water network.

ix) Fire water pressure at the farthest point shall be a minimum of 7 Kg/cm2 after installation of headers and sub headers.

x) F.W. header/line shall be laid in RCC trench on pedestal supports with sand filled and covered with pre-cast slab. Cathodic protection also to be considered for underground/trenched piping.

xi) Fire water shall not be used for any other purpose.

6.0 FIRE WATER SYSTEM
Fire Water System shall be designed as per TAC guidelines / NFPA Code and complied with Local Law/ Civil Defence requirements.

6.1 Fire Fighting System

1) Fire Hydrant shall be provided in a ring round the facilities of all process plant area in the LSTK scope.

2) Fire Fighting System design and layout is subject to review and approval by Local Authorities.

3) LSTK contractor shall calculate the fire water requirement for their scope and tie-in for LSTK scope shall be taken from the OSBL fire water network. Offsite fire water network (OSBL scope) shall be available around the unit. Contractor shall take two nos. of tapings from Offsite header with an isolation valve for each tapings.

4) Valves on fire water mains shall be of Gate type only. Valves on fire water lines shall be located in RCC valve chamber provided with top cover to facilitate easy operation/ maintenance of valves. The top of chamber shall be 80 mm above ground level.

5) The bidder shall identify the fire risks for the proposed plant and provide appropriate fire protection equipment accordingly. It is expected that these will include (but not necessarily be limited to) the following:
   i) Fuel (coal, oil & natural gas) handling and storage plant including oil pump house, coal conveyors, terminal buildings, crusher house/ coal mills and coal bunkers.
   ii) Boiler feed pump set oil systems
   iii) Oil filled transformers
   iv) Records / library rooms
   v) Control rooms
   vi) Cables, Electrical Bays (switch gear room, MCC room, cable cellar/ cable spreader room etc.)
   vii) Ash Handling Area
   viii) Diesel engines and fuel tanks
   ix) Boiler light up gas store and pipe-work
   x) Hydrogen filled machines, store and pipe-work
   xi) All other indoor and outdoor stores where any inflammable substance may be present
   xii) All Buildings, equipments coming under scope of LSTK Contractor's Battery Limit.

7.0 Technical Requirements

7.1 Hydrant System

Pressurized fire hydrant system will consist of a pipe network and hydrants positioned around the station in sufficient numbers and so located that all buildings and risks are readily protected. Necessary number of loops will be formed around various risks. The loops will be interconnected for better reliability of the system. To isolate a portion of the ring main because of damage/repair, suitable nos. of valves will be provided.

The hydrant network will be sized and analysed to ensure that about 7.0 Kg/cm² pressure is available at the hydraulically remotest point in the system with the hydrant pump discharging at
rated head and capacity. The velocity in the hydrant main will not exceed 3 m/sec. Hose pipes of suitable lengths along with standard accessories like branch pipes, nozzles, spanners, etc. will be provided. These will be kept in a central hose house for the outdoor hydrants. Each internal hydrant valve will be provided with individual hose box having glass front containing hose pipes, hose reel, branch pipes and nozzles etc.

- The general design of Double headed hydrants valve shall conform to IS:5290 type A and material of construction shall be stainless steel.
- The general arrangement stand post assembly, consisting of a column pipe and a hydrant valve with a quick coupling end shall be as per requirement of TAC with respect to outdoor and indoor operation suitability.
- Material of construction for Branch pipes shall be Stainless steel (SS-304) and it shall have rings at both the ends. One end of the branch pipe will receive the quick coupling while the nozzle will be fixed to the other end.
- The general design and construction of instantaneous couplings, branch pipes and Nozzles shall be as per IS: 903 (latest edition). Metal couplings at both ends of hose pipes shall be of SS.
- 2 Nos. 15m long RRL type Hose pipe 63 mm size conforming to IS: 636, fitted with quick coupling ends, branch pipes, nozzles, spanner etc. shall be kept in a hose box, which shall be located near point of use.
- Fire Water Monitors shall be provided when height of the structure, tower exceeds 15 mtr and the same shall be as per IS:8442.
- There may be cases where due to horizontal obstruction, a particular vessel/ process column may not be approachable by ordinary monitor or hydrant, elevated long range monitors shall be provided to take care of such conditions.
- Fire hose reels shall be considered at strategic locations around block as first aid fire contingency. These shall be floor mounted type and shall have water connection from hydrant network. Each hose reel shall have 30 meter long hose with nozzle. Hose reel shall be located as per Std. (IS 884) and should cover all process areas in ground floor. Additional hose reels shall be provided with each landing valve. Hose reel shall be 30m x 20mm bore.

7.2 Water Spray System

Water spray systems provided shall meet the requirements of NFPA /TAC, and job specifications. The rate of water applications and mode of operation shall be as per TAC/Standards. Low point drains shall be provided in the water spray network.

Linear heat sensing device shall be provided for all floating roof tanks, if applicable. Automatic fixed water spray system shall be provided for the cable cellars of Sub-station and the oil filled transformers and Diesel/LDO/Fuel Oil Tank. The system shall be designed in accordance with NFPA 15/TAC.

7.3 Clean Agent System

The Automatic clean agent protection system shall be provided in control rooms as Per NFPA 2001. The system shall be designed to meet the minimum requirement of total flooding, fire detection, actuation extinguishing requirements as per NFPA 2001. The actuation of clean
agent system shall be indicated in the control panel located in the fire station control room & CCR. Preferred clean agents are either Argonite or Inergen only.

7.4 Portable Fire Extinguishers

Following types of portable and mobile CO2, dry chemical powder and foam type fire extinguishers shall be provided for the entire Steam generation plant area at agreed locations as per NFPA requirements. Contractor shall specify the numbers and location for Owner's review and approval.: 

- 2 kg capacity dry chemical powder fire extinguisher.
- 6 kg capacity dry chemical powder fire extinguisher.
- 9 kg capacity dry chemical powder fire extinguisher.
- 2 kg capacity CO2 type fire extinguisher.
- 4.5 kg capacity CO2 type fire extinguisher.
- 50 litre capacity Foam type fire extinguisher

8.0 Piping System and Valves

Complete piping, valves, fittings, specialties and pipe supports and necessary electrical item for the fire protection system shall be provided by LSTK Contractor inside the Battery limit of Proposed Steam generation plant.

Hydrant, monitor and spray system piping will be run underground and through Hume pipe at road crossings. Piping will be of carbon Steel pipes (galvanized or ungalvanized) of 'Medium' grade confirming to IS: 1239/3589 or equivalent acceptable international standard and coating and wrapping as per IS: 10221. Provisions will be made for extension of hydrant and spray system piping for future extension of the project.

Piping for compressed air, breaching connections, drains, downstream of deluge valves will be of heavy grade galvanized type.

Pipes shall be provided with vent connection and vent valves at all high points and drain connection & drain valves at all low points. All firewater piping shall be capable of being drained completely and provided with drain cocks / valves at low levels.

Isolation Valves at every 300 m and at crossings (junctions) to ensure easy maintenance and uninterrupted water supply in case of break down. All isolation valves in Hydrant system shall be non rising spindle type Gate valve only (For Under Ground Pipelines) and OS&Y type (for Aboveground headers). Isolation Valves above 200 mm NB shall be gear Operated. Material of construction of Gate/Globe/Check valves & strainers shall be carbon steel. No Cast iron valves & strainers shall be used.

At every 300m and at crossings (Junctions) to ensure easy maintenance and uninterrupted water supply in case of break down and shall be planned in such a way that outage of any section of fire water line should not affect other section. Isolation valves shall also be provided below monitor and at all hydrants. Landing valves on tech structure, platforms, columns, buildings, shall have individual 4" isolation valve at each hydrant. Isolation valve shall be provided at all tapping points on firewater headers.
9.0 SAFETY EQUIPMENTS

LSTK contractor shall provide the following safety items (BIS approved) with minimum qty. specified for their scope of work:

a) Safety helmets – 10 nos. per control room & per substation.
b) Stretcher – 4 nos.
c) Fibre glass First Aid Box with all necessary items/kit & Anti snake serum - 2 nos.
d) Rubber hand gloves for electrical jobs – 10 pairs for each substation and each control room.
e) Explosimeter - 2 nos.
f) Fire Proximity suit – 4 nos.
g) Rescuscitator – 2 nos.
h) Electrical siren (3 Km range) - 1 no.
i) Hand operated siren – 2 no.
j) Water jel blanket – 4 nos.
k) Red/Green flag for fire drill – 10 nos. each color
l) Positive Pressure type self contained breathing apparatus – 4 nos. per control room & per substation.
m) Hand held battery loaded Emergency light, each with 1 set spare battery - 4 nos.

10.0 SAFETY IN SYSTEM DESIGN

10.1 Spacing and Layout

CONTRACTOR to finalise hydrant layout on plot plan, with all the requirements such as number of Hydrants, Monitors, Foam system, sprinkler system etc., based on all statutory requirements & TAC Guidelines, considering ease of maintenance and safe approach for fire fighting. Due consideration is to be given for providing Emergency escape routes also. Hydrants are to be strategically located to obtain maximum advantage of layout.

11.0 EXECUTION, INSPECTION AND TESTING

All execution, inspection and testing for completion of fire protection system shall be carried out based on Codes, standards and specifications. LSTK Contractor shall develop a detail inspection, and testing procedures based on codes, standards and specifications. Following minimum tests but not limited to, shall be carried out after completion of the system testing Fire water network piping:
a) Demonstration test for system capacity requirements
b) Demonstration test for auto start and stops for the main fire pumps and jockey pumps, if applicable.
c) Demonstration test for foam application
d) Demonstration test for water spray
e) Demonstration test for CO2 system (using N2 in place of CO2), if applicable.

The LSTK Contractor shall meet all requirements for inspection and testing of the system.

12.0 APPROVAL OF DRAWING

Drawings and documents shall be prepared as required by approval authorities in all respects and submitted by the LSTK Contractor. The LSTK Contractor shall make arrangement for inspection and testing for statutory authorities at various stages of the work.
1.0 Detection, Actuation, Alarm and Communication System

For detail refer electrical and instrumentation specifications attached with the bid document

1.1. General Features Design

a) An addressable type of Fire Alarm System shall be provided for the plant. The design shall be as per NFPA and applicable local requirements.

b) The fire protection facilities for the Project shall meet the local rules and requirements. These facilities include providing smoke and heat detectors in the buildings.

1.2 Salient Features

1.2.1 Smoke/Heat Fire Detection

The fire detection system shall be made by means of optical smoke detectors, ionization smoke detectors and heat detectors. The above system shall be installed in the control room, electrical substations and other buildings. The signal coming from the above detectors shall be sent to Local Fire Alarm Panels at various locations and in turn to the Main Fire Alarm Panel.

1.2.2 Alarm Push Button Outdoor/Indoor

Outdoor/indoor Alarm push button shall be located in the plant area/buildings so that the maximum travelling distance is no more than specified as per NFPA Code. The push buttons shall send the signal to the respective Fire Alarm Panel at various locations.

1.3 Fire Alarm Monitoring System

1.3.1 General

Fire Alarm Main Control Panel shall be provided in Fire Station Building and Sub Control Panels (Local Fire Alarm Panels) shall be provided, one each in control room, and other agreed location. Fire alarm control panels shall be provided in the respective Non-plant buildings. Interconnection of these fire alarm panels to the main fire alarm shall be done by the Contractor. Summary of Fire alarm to be connected to DCS shall be prepared and approved by Owner.

1.3.2 Each fire alarm panel shall be suitable for the following tasks:

a) To receive signals coming from:

- Smoke detection and heat detection systems
- Manual push buttons to actuate audible and visible alarm for each received signal and a siren for general alarm.
b) The control panel shall supply operating low voltage D.C. to the system and have an in-built charging system to maintain in-built batteries, which shall operate the system in the event of mains failure. EDG/UPS power connection shall be provided the fire alarm system.

c) There shall be sufficient zones on the panel to quickly identify the area of alarm. Such zones shall either indicate the area on the panel in English with standard model available in the market. NFPA code for zone classifications shall be followed.

d) The panel shall be capable of supervising faults on the alarm lines, battery leads, batteries, sounders, and contain both audible and visual warnings of such faults within the panel. Only the use of a supervisory key should control such fault indications. Fire conditions must always overcome faults. Indicating lamps shall be dual filament type, having twin lamp circuits or LED type.

e) It is preferred that the panel shall have an "alarm" and "evacuation" circuit on an automatic basis so that the "alarm" signal shall move to "evacuate" signal within a given period unless controlled with key by a responsible person.

f) The alarm shall be by electronic hooter and siren capable of giving two distinct sounds - one "alarm" the second "evacuate". The number and location of such hooter and siren shall be determined by a qualified fire protection engineer and be designed to be clearly heard above background noise of the operating plant. The cable feeding the alarm system shall be monitored and protected from fire. Cables for fire alarm system will be fire retardant type. However, the cables and components shall comply with the local regulation requirements.

g) Manual alarm shall be given by break glass call points which shall be located beside all exits to the open air, or from the department to a safe route, and at all points of high risk. The glass shall be of the fiber glass reinforced plastic type and of copper free aluminium in hazardous area and a test facility shall be incorporated. The instructions shall be in English.

h) Alarm points in external conditions shall be weather proof and where conditions require this, be explosion proof.

i) In areas of high background noise, flashing or rotating lamps shall be placed alongside hooter /siren to give visual as well as audible warning.

j) The system shall also be capable of:
   - Accepting automatic detection systems.
   - Closing down air conditioning or similar functions.
   - Having repeater mimic panels added to the system.
   - Serial interface between main fire alarm panel and DCS (to be displayed F&G console) shall be provided. Necessary alarms shall be repeated on DCS.

k) The use of taped voice messages in English in conjunction with alarm sounder shall be provided.
SECTION: VI – 5.3.6

DESIGN PHILOSOPHY – HVAC SYSTEM

PLANT: STEAM GENERATION PLANT

PROJECT: INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA).
## CONTENT

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1.0 GENERAL

1.1 Intent:

1.1.1 This Philosophy states that LSTK Contractor’s/ Bidder’s scope of work shall include basic & detailed engineering, procurement, supply, manufacturing, fabrication, inspection & testing, transportation, loading, unloading, insurance, storage, construction, erection/ installation of all HVAC (Heating, Ventilation, Air Conditioning) System / package with auxiliaries viz. chiller units, chilled water pumps, condenser water pumps, cooling towers, air handling units, package/portable AC units, Ventilation system, piping, electrical, instrumentation and civil works, obtaining all necessary statutory approvals from concerned government authorities as applicable, testing, mechanical completion, pre-commissioning, commissioning, performance guarantee test runs including total project management and handing over of complete HVAC System / package for Steam Generation Plant for Talcher Fertilizer Limited at Talcher, Angul District Odisha (India).

1.2 Scope of work:

1.2.1 LSTK Contractor shall provide suitable HVAC system for all process / non-process buildings/ facilities mentioned in the NIT as well as for other buildings/structures also, which are not specifically mentioned in the NIT, however, required in view of plant’s operational needs, shall be in the bidder's scope.

Indicative list wherein HVAC system are required:
1. Control room(s)
2. Sub-station(s)
3. Lab Tech Building(s)
4. Field Maintenance office(s)
5. Operator cabins
6. Lift machine rooms
7. Chemical storage shed
8. Feeder panel rooms
9. Other miscellaneous building, if any.

1.2.2 Type of Air conditioning system and Ventilation system are preferably required as under for various above mentioned buildings / facilities:

1. Control room (s): Central AC system with complete auxiliaries with 100% stand-by chillers & AHUs are required with chemical filters.
2. Substation Buildings: Central AC system with complete auxiliaries with 100% stand-by chillers & AHUs are required with chemical filters.

3. Lab Tech Building(s):
   a) Gas analyzer room, Chemical testing room, inst analysis room, chemical storage room in lab building shall have central AC system/package ACs with 100% stand-by.
      The treated air shall be distributed by ducts from air handling unit to each room and the return air from laboratory rooms shall not be mixed.
   b) Laboratory fume cupboards exhaust by ventilation fans along with standby units. Individual ventilation system with draught chamber shall be provided for laboratory room as necessary.
   c) Office in lab tech buildings shall have portable ACs with stand-by units.

4. Field maintenance offices: shall be air-conditioned through portable ACs with stand-by units.

5. Lift machine room: shall be air-conditioned through portable ACs with stand-by units.

1.2.3 Ventilation system with adequate stand-by equipment to be provided not limited to the following buildings:

- Battery rooms (explosion proof fans with 100% stand-by)
- Maintenance rooms
- Pantry room
- All Toilets
- Plant room
- Clean agent room
- AHU (Air Handling Units) Rooms
- Locker rooms
- Electrical room
- Cable cellar (explosion proof fans with 100% stand-by)
- Store rooms
- Change rooms
- Chemical, Lube oil and Bulk storage shed

Bidder to please refer ISHRAE/ASHRAE guidelines for Industrial Ventilation as prescribed in NIT. However, minimum assumption shall be:

i) 20 ACPH for toilet
ii) 20 ACPH for Battery Room
iii) 10 ACPH for Cable cellar area
iv) Actual ventilation required by Fume cupboards
v) 20 ACPH for plant room

1.2.4 Philosophy for Split AC/Cassette AC/portable AC/package units shall be opted as:

Bidder to note that for centralized AC system 100% redundancy shall be there as per NIT requirement. Moreover, for package AC/Split ACs dedicated for ‘plant equipment’ shall have 1W + 1Standby (100% standby) concept.

Split ACs/Portable ACs dedicated for human habitation/officer’s cabins shall have no redundancy.

1.2.5 Noise level shall be limited to 70 DBA at 1 meter distance from the equipment complying national & state regulation.
1.2.6 Bidder to assure that HVAC system and auxiliaries shall be complete in all aspect complying to national / international / statutory requirement and bidder shall furnish their selection and design calculation of HVAC system w.r.t various buildings/ facilities during detail engg for owner’s review and approval. 
**Bidder to also note that atleast 20% extra Design margin for HVAC to be considered above peak load requirement.**

2.0 CODES AND STANDARDS:

2.1 The *Latest Edition* of codes and standards as listed below shall be followed for design and manufacturing of different machinery / package items.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>IS: 659</td>
<td>Safety code for Air-conditioning</td>
</tr>
<tr>
<td>IS: 660</td>
<td>Safety code for Mechanical Refrigeration</td>
</tr>
<tr>
<td>IS: 655</td>
<td>Metal Air ducts</td>
</tr>
<tr>
<td>IS: 2494</td>
<td>V-Belts for Industrial Purposes.</td>
</tr>
<tr>
<td>IS: 3142</td>
<td>V-Grooved Pulley</td>
</tr>
<tr>
<td>IS: 1239</td>
<td>Mild Steel Tubes</td>
</tr>
<tr>
<td>IS: 3589</td>
<td>Seamless or electrically welded steel pipes for water, gas and sewage.</td>
</tr>
<tr>
<td>IS: 277</td>
<td>Galvanized Steel Sheets (Plain and Corrugated)</td>
</tr>
<tr>
<td>IS: 2062</td>
<td>Steel for General Structural Purposes.</td>
</tr>
<tr>
<td>IS: 3103</td>
<td>Code of Practice for Industrial Ventilation</td>
</tr>
<tr>
<td>IS: 4894</td>
<td>Test Code for Centrifugal Fans.</td>
</tr>
<tr>
<td>IS: 8148</td>
<td>Packaged Air Conditioners.</td>
</tr>
<tr>
<td>ISO/HIS</td>
<td>Centrifugal Water Pumps</td>
</tr>
<tr>
<td>ARI-450</td>
<td>Remote mechanical draft air cooled refrigerant condensers, Remote Type</td>
</tr>
<tr>
<td>ARI-460</td>
<td>Refrigerant cooled liquid coolers, Remote Type</td>
</tr>
<tr>
<td>ARI-480</td>
<td>Positive displacement refrigerant compressor and Condensing units</td>
</tr>
<tr>
<td>ARI-520</td>
<td>Water Chilling Packages using Vapour Compression Cycle.</td>
</tr>
<tr>
<td>ARI-550/590</td>
<td>Water Chilling Packages using Vapour Compression Cycle.</td>
</tr>
<tr>
<td>ASME Section VIII Div.</td>
<td>Code for unfired pressure vessels</td>
</tr>
<tr>
<td>TEMA</td>
<td>Tubular Exchanger Manufacturers Association.</td>
</tr>
<tr>
<td>SMACNA</td>
<td>Sheet Metal and Air Conditioning Contractors' National Association.</td>
</tr>
<tr>
<td>AMCA-210</td>
<td>Laboratory Method of Testing Fans for rating purpose</td>
</tr>
<tr>
<td>ASHRAE/ISHRAE</td>
<td>Handbooks of :</td>
</tr>
<tr>
<td></td>
<td>- Fundamentals</td>
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<tr>
<td></td>
<td>- HVAC Systems and Equipments</td>
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<tr>
<td></td>
<td>- HVAC Applications.</td>
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<td>- Refrigeration</td>
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<tr>
<td>BS-6540 Part-1</td>
<td>Method of Test for atmospheric dust spot efficiency and synthetic</td>
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<td>dust weight arrestance.</td>
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<tr>
<td>BS EN 779</td>
<td>Particulate air filters for general ventilation – Requirements, testing</td>
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<td>marking.</td>
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2.2 Other international standards may also be acceptable subject to their being equivalent
or superior to those listed above, with prior approval of owner.

2.3

For provisions not covered by the above codes and standards, applicable good engineering practices and norms shall govern.

3.0

TECHNICAL REQUIREMENT:

3.1

Duty

3.1.1

HVAC system/package to be designed considering continuous 24 hours operation for all concerned areas. The plant shall be suitable for maintaining inside design conditions all the year round. Notwithstanding the duty specified, all equipment shall be suitable for continuous operation for 8000 hrs. per year.

3.1.2

Heat load calculation of entire area of plant Building/Facilities shall be done by bidder and AC plant shall be selected on the basis of heat load calculation. Bidder has to submit heat load calculation of the various building including different area and bidder to furnish type of HVAC plant with technical details in his offer.

3.1.3

Outside atmospheric condition shall be referred as given elsewhere in process design philosophy of NIT.

Inside condition of various major areas under all weather condition i.e. summer, monsoon and winter shall prevail as under:

<table>
<thead>
<tr>
<th>Area</th>
<th>Required Inside temperature</th>
<th>Required Relative Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control rooms</td>
<td>22 ±2 °C</td>
<td>55 ± 5%</td>
</tr>
<tr>
<td>Sub Stations (Switchgear rooms)</td>
<td>22 ±2 °C</td>
<td>55 ± 5%</td>
</tr>
<tr>
<td>Rack rooms</td>
<td>22 ±2 °C</td>
<td>Rack room equipment OEM requirement to be followed.</td>
</tr>
<tr>
<td>PLC room</td>
<td>22 ±2 °C</td>
<td>PLC OEM requirement to be followed.</td>
</tr>
<tr>
<td>UPS room</td>
<td>22 ±2 °C</td>
<td>UPS OEM requirement to be followed.</td>
</tr>
<tr>
<td>Computer room</td>
<td>22 ±2 °C</td>
<td>OEM requirement to be followed.</td>
</tr>
<tr>
<td>Any other ‘plant equipment’ building / room</td>
<td>22 ±2 °C</td>
<td>OEM requirement to be followed.</td>
</tr>
<tr>
<td>Meeting rooms, conference rooms, executive separate Cabins/room, staff rooms, dining halls, Kitchens where human occupancy is predominant.</td>
<td>22 ±2 °C</td>
<td>55 ± 5%</td>
</tr>
</tbody>
</table>

Other plant building/facilities shall also be equipped with adequate HVAC system by LSTK contractor.
3.2 Refrigerant:
R-134a / equivalent and Eco-friendly refrigerant to be supplied & filled in the chiller units by LSTK Contractor.

3.3 Chilled units (with Centrifugal Refrigerant Compressor):
The compressor shall be of proven design based on national / international standards unless otherwise mentioned in specification.
Chiller units shall have proven track record of satisfactory operation for a minimum period of 8000 hours for process / power plant industry.
Casing hydraulic/pneumatic test pressure shall be at least 125% respectively of design pressures.
Refrigerant gas/water cooled oil cooler, thermostatically operated electric oil heater, oil pressure regulator, oil filter, shall form part of lubrication system.
Automatic capacity regulation feature is desired on compressor along with manually operated device.
Purge recovery unit, if required, shall be provided to efficiently separate out non-condensable gases and moisture from refrigerant as per Manufacturer's Standard.

3.4 Chiller units (with Screw Refrigerant Compressor- hermetic or semi hermit sealed units):
The compressor shall be of proven design based on national / international standards unless otherwise mentioned in specification and the offered model shall have proven track record of satisfactory operation for a minimum period of 8000 hours for process / power plant industry. The compressor shall be equipped with automatic unloaded starting arrangement. It shall have automatic sliding valve capacity control arrangement actuated through suction pressure sensor.
Compressor unit shall be complete with base frame, control desk with gauges, suction strainer, suction and discharge valves with check valves, drive motor, drive arrangement, motor driven oil pump / rotor shaft driven built-in oil pump.

Reciprocating Chiller Units shall not be acceptable.

3.5 Water cooled Condenser:
The tubes shall not be less than 12.5 mm diameter and shall be adequately supported to prevent tube vibration.
Condensers for rated AC plants shall have water boxes and covers to that each tube sheet can be exposed without disturbing the piping connections.

3.6 Evaporator / liquid cooler:
Tubes shall not be less than 12.5 mm diameter and Tubes shall be adequately supported to prevent tube vibration.
Condensers for rated AC plants shall have water boxes and covers to that each tube sheet can be exposed without disturbing the piping connections.

3.7 Refrigeration Packaging Assembly:
Skid shall be designed so as to provide maintenance accessibility and operation ease of valves and controls. Instruments shall be easily readable.
Lifting hook/eye shall be provided for handling of equipment during maintenance.
Steel structural members of the skid shall conform to IS-2062 / ASTM A 36.
3.8 Air Handling Unit:

Air-handling unit shall be of double skin with insulation in sectionalized construction for convenient transportation and installation. The air handling unit shall comprise of filter section, damper section, heating section (if required), humidifier section (if required), cooling coil section, fan section and drain pan.

Cooling coil shall be minimum 4 rows deep.

Dampers section shall have face and bypass damper. Bypass area shall not be less than 1/4th of the face area.

Filter section shall be provided with Chemical filters, as applicable.

Filters shall be selected for a pressure drop of maximum 4mm WG in clean condition.

Filters (prefilter + fine filter assembly) shall be capable of filtering up to 5-micron dust particles with an efficiency of more than 95%.

Inclined tube manometer with tubing shall be provided on AHU for indication of pressure drop across the filters.

Fan selection will have centrifugal type with electric motor. Fan rotating assembly shall be dynamically balanced. Flame resistant flexible bellow connection with metallic flanges shall be provided between fan outlet and duct.

Taper lock pulleys shall be provided with wedge type belts for drive. However, Direct coupled Fan with motor with flexible coupling shall be more preferred.

Grease cups shall be provided for fan bearings.

Drain pans for condensate shall be of stainless steel (18/8 grade) construction and thermally insulated. Water seal shall be provided in the drain outlet.

Ribbed neoprene rubber pads shall be provided as vibration isolators for the Air handling unit.

3.9 Chemical Filters:

Chemical filters shall be designed & selected by bidder for the indoor condition for Control room(s) and Sub-station(s) considering the worst surrounding atmosphere of plant.

Chemical filter shall be selected for the chemical media life of minimum 2 years.

Outside gas concentration shall be considered while evaluating the life. Chemical filter’s nomographs etc to be submitted by LSTK Contractor in support of the chemical media life.

Chemical air filter unit shall be skid mounted cubicle for horizontal installation.

Three stage chemical filter shall be provided.

Chemical filter shall have adequate provision for easy removal & servicing of filter packs. Bidder to provide differential pressure indication across filters and velocity across the filter shall be in range of 100-110 FPM.

3.10 Heating Unit:

Heating shall be preheating and / or Reheating as per psychometric Process requirement.

Heating shall be with electrical heaters.

Electric strip heaters, if provided, shall be complete with heating thermostats/humidistat, safety thermostats and contractors.
3.11 Humidifier Unit:
Humidifier shall be steam pan type or water spray type.
Pan humidifier shall be complete with immersion type electric heaters actuated by humidistat, water float valve, stop valve in water make up line, level switch interlocked with heaters. Pan/ storage shall be fabricated with 18/8 grade stainless steel. The outer surface shall be thermally insulated.
Water spray type humidifier shall comprise of spray header, nozzles, arms, pump sets, humidistat, solenoid valve etc. Make up tank, water collecting trough complete with drain, quick fill, overflow, strainer make up connection with ball and float valve and isolating valves shall be provided.
Drain pan/water collecting trough of water spray humidifier shall be of stainless steel construction and thermally insulated.
The humidifier shall be sized to deliver 110% of capacity required.

3.12 Cooling Tower:
Cooling tower shall be natural or induced draft type in FRP construction. Cooling tower fan shall be of FRP blades directly mounted on the shaft of totally enclosed weather-proof (IP-55) motor with suitable weather proof canopy hood. The fan shall be protected by guard. The fan assembly shall be dynamically balanced.
Service ladder shall be provided for the cooling tower.
Water basin shall be made of F.R.P. and provided with suction strainer.
The cooling towers shall be provided with drift eliminator.
Supporting framework for the cooling tower shall be made of galvanized steel and further lined with FRP.
Cooling tower structure shall be designed to withstand wind load as specific, per IS-875.
Local lockable push button station in weather-proof enclosure with a canopy cover shall be provided.

3.13 Water Pumps:
Pumps shall preferably be back pullout type with mechanical seals.
Pumps shall be designed and selected by considering overall requirement of the AC plant, condenser water circuit and chilled water circuit, NPSH, pressure & temperature of the liquid etc and shall be provided with mechanical seal.
The pumps shall be complete with drive motor, coupling with non-sparking guard, common base plate, fixing and hold down bolts.
Bidder to note that nos. of chilled water pump & condenser water pump sets shall be selected as the numbers of chiller units plus one set of chilled water & condenser water pumps shall be operated as in standby mode. However, chilled water pumps and condenser water pumps shall have their respective common headers at inlet/outlet to ensure availability and interchangeability of pumps in all condition.

3.14 If not specifically mentioned, all continuous operating machine shall have 100% standby.
3.15 Refrigerant Piping:
All piping network shall be leak tested with nitrogen at 1.25 times of design pressure using soap water solution followed by electronic / halide torch leak detection. The piping network shall be further pressure tested with nitrogen at 1.25 times of design pressure for minimum 24 hours. After establishing the capability to withstand test pressure, the piping network shall be dried and vacuumized to 2.5mm Hg absolute. Vacuum shall be broken with dry nitrogen and the system shall be revacuumised to 2.5 mm Hg absolute. This vacuum shall be held for 12 hours before charging the refrigerant.

3.16 Water Piping:
All water piping shall be of Carbon steel and all chilled water and condenser water piping shall be complete with, flanges, fittings, valves, strainers, gasket & fasteners, hanger/supports etc.

3.17 Fire Dampers:
Fire dampers shall be installed in supply air and return air path. These shall conform to UL555 for 1.5 hour fire rating. The fire dampers shall be spring return, motorized & fail safe type with indication for open and Close position. Fire damper operation shall be interlocked (through HVAC Panel) with the Signal from purchaser's fire and gas panel.

3.18 HVAC system interlocks with plant Fire and Gas system:
Unless otherwise specified, all the HVAC system of project will be interlocked with plant Fire and GAS system as follows complying to statutory requirement:
Fire alarm signal from fire and gas system to HVAC control Panel: Whole HVAC system shall shutdown.

3.19 Equipment Automatic Change over requirement:
Change –over from duty to stand-by equipment, in case of failure of the duty unit, shall be fully automatic. Automatic Change over shall be provided to switch, on weekly basis, the duty and stand-by equipment, in order to ensure an even number of running hours for each units.

3.20 Expansion Tank (for Chilled Water System only):
Expansion tank shall be provided by vendor and installed at-least 1 m above the highest point of the system. Tank shall be of minimum 500 liter capacity (unless otherwise required because of System design requirement) fabricated from 18/8 grade stainless steel min 3 mm thick with all requisite stiffeners. The tank shall be complete with float valve assembly backed up with Gate valve for make up, quick fill gate valve, drain with valve and overflow. Tank shall have rigid supporting arrangement. All piping and instrumentation shall be in scope of contractor only.
3.21 Portable AC/ Split AC/ Package AC shall be used wherever required with optimization of energy consumption. Minimum 3 star BEE-Star rating to be used for the same. Window AC shall be avoided. Adequate stand-by units are to be provided as per this specification.

3.22 **Plant Room Ventilation:**

A.C. Plant room shall be forced ventilated by wall mounted exhaust fan(s) complete with electric motor, louver shutter and 18/8 grade stainless steel wire protection guard on intake side of exhaust fans. The capacity shall be decided based on 20 air changes per hour. Air intake weather protection louvers along-with bird protection screen shall be provided with suitable structural steel frame in wall.

3.23 **Air Distribution, Ducting, Diffusers /Grilles:**

Ducts shall be designed, fabricated and flanged as per IS-655 for static pressure up to 65 mmWG. In case, static pressure is more than 65 mmWG, SMACNA code shall be followed for design and fabrication of duct. Duct hangers shall be supported with anchor fasteners in the roof. Anchor fasteners shall be provided by vendor. All flange joints shall have minimum 6 mm thick Neoprene packing as gasket stuck to the flanges with adhesive (viz., resins like araldite or equivalent). All the duct shall be made air tight with the help of sealant.

Ductwork shall be provided with following accessories.
- Turning Guide Vanes.
- Extractor with operating lever.
- Splitter Damper with control rod & locking device.
- Volume control Damper (opposed bladed type with 16 gauge with ~ 250 mm wide blades and 14 gauge casing of Galvanized Sheet Steel).
- Fire resistant flexible connection between duct chute and diffuser (if required).
- Access doors for heaters, fire dampers and filters.

Supply air diffusers or grilles, as required, shall be provided and shall be fitted with sponge foam tape. Volume control damper shall be provided with each supply air diffuser/grille. Volume control damper shall be key operated from the front of diffuser/grille. Supply air grilles shall be provided with vertical & horizontal adjustable louver

All return air diffusers/grilles, if required, shall be without volume control damper. Diffusers/grilles shall be of powder coated steel construction with angle frame. Diffusers/grilles shall not be supported from False Ceiling. All ducting shall be designed and laid out as per requirement of various area of CCR Building so that an efficient layout may be done. LSTK Contractor to submit a complete P&ID,GA of entire AC plant and duct layout proposed/ envisaged by LSTK Contractor for Owner’s review and approval.

3.24 **Insulation:**

Surfaces to be insulated shall be thoroughly cleaned and allowed to dry. Pneumatic/hydraulic test, if any, shall be carried out before insulation. Insulation material shall be high class fire resistant material and ‘Non Combustible’.
a) **Hot Insulation:**
Bare surfaces of pipe/equipment shall be provided with one coat of 20 micron min. (dry film thickness) heat resistant primer up to 125°C operating temperature. Resin bonded mineral wool conforming to IS-8183 shall be used for hot insulation. Preformed pipe sections/mattresses of min. density 120 kg/m³ shall be used. Hot insulation shall be cladded with 24 SWG aluminium sheeting.

b) **Cold Insulation:**
The pipes and duct shall be insulated and finished as per this specification. Sound Attenuators shall be installed in ducts, as required.

For all inspection covers and hatches on equipment, pump casing, valve bodies & flanges more than 100 mm dia, the insulation shall be applied so as to facilitate removal without its damage. This shall be achieved by encasing the insulation in 24 gauge aluminium sheet metal sections, which are screwed together around the equipments to permit easy removal and replacement maintaining continuity of vapour seal.

The insulation materials shall be:
- i) Resin bonded fiber-glass of 24 kg/m³ density to IS: 8183.
- ii) Poly isocynurette of 32 kg/m³ density to IS: 12436.
- iii) Phenolic Foam of 32 kg/m³ density to IS: 13204.
- iv) Polyurethane Foam of 32 kg/m³ density to IS-I2436.

The application, insulation material and recommended thickness are given in Appendix of this tech specification.

c) **Underdeck insulation:**
Phenolic foam underdeck insulation shall be of rigid slab of 25 mm thickness and approx. 1000 mm x 500 mm size and shall conform to IS:13204. It shall have density of 32 kg/m³ and K value of 0.0034 w/mk at 53 deg. Mean temperature. The insulation shall be classified as ‘Non Combustible’ as per BS 476. It shall be pre-laminated on both sides with kraft paper.
Entire surface of slab and beams shall be thoroughly cleaned. Bituminous primer or zinc chromate primer shall be applied evenly @ 0.5 kg/m² over the entire surface. Hot bitumen or CPRX adhesive shall then be applied on the insulation panel @1.5 Kg/ m². The panels shall be pressed in position and further secured by dash fasteners.
Underdeck insulation shall be fixed only after all fixtures like hooks, clamps, cleats etc for light fixtures, ducts etc. have been fixed in the ceiling.
3.25 Controls And Instrumentation:

Vendor shall include all controls & instruments as required for safety & operational requirements of the plant.

Automatic operation of all controls wherever feasible is required, with manual overdrive for maintenance etc.

All control shall be suitably interlocked for safe & sequential operation of plant generally in the following order:

a) Start AHU blower.
b) Start Cooling tower fan.
c) Start Condenser water flow/condenser fan.
d) Start Chilled water pump.
e) Start Refrigeration unit/compressor.

While shutting down the plant, equipment will stop in the reverse order as listed above.

Humidifier heaters shall be actuated by humidistat.

Potential free contact shall be provided by vendor for closing motorised fire dampers and simultaneously tripping the AHU blower motor on receiving the fire signal from purchaser's Fire & Gas Panel. On expiry of fire signal, fire dampers shall open manually through reset button.

A) Requirements for Centrifugal compressor / chiller package:

The control panel shall be machine mounted In cubicle construction per manufacturer's standard design and shall have protection against following situation as a minimum.

i) High condenser pressure.
ii) Low oil pressure.
iii) High bearing temperature switch for compressor.
iv) Low evaporator pressure.
v) Low chilled water flow.
vi) Low condenser cooling water flow
vii) Overload protection for all motors.
viii) Low chilled water temperature.
ix) Excessive vibration switch.
x) Purge pump high discharge pressure.
xi) High lube oil temperature to cut off heater supply.
xii) Anti freeze.
xiii) High Compressor discharge temperature.
xiv) Oil Filter differential pressure.
xv) To ensure opening of inlet guide vanes after compressor motor has stabilized.
xvi) Motor current limiter.
xvii) To ensure close guide vanes at start-up.
xviii) Low water level in humidifier tank.
xx) Air heater change over switch.
xx) Air flow switch.
B) **Requirements for Screw compressor/ chiller package:**

Local Control desk with gauges shall be machine mounted in cubicle construction provided with:

i) Suction & discharge pressure gauges.

ii) Suction & discharge pressure switches.

The control panel shall be either machine mounted or floor mounted in cubicle construction as per manufacturer's standard design and shall have protection against following situations as a minimum:-

i) Low oil pressure.

ii) High bearing temperature switch for compressor motor.

iii) Low oil temperature.

iv) Low chilled water flow.

v) Low condenser cooling water flow.

vi) Overload protection for all motors.

vii) Low chilled water temperature.

viii) High lube oil temperature to cut off heater supply.

ix) Anti freeze.

x) High Compressor discharge temperature.

xi) Oil Filter differential pressure.

xii) Motor current limiter.

xiii) To ensure minimum position of slide valve at start-up.

xiv) Low water level in humidifier tank.

xv) Air heater change over switch

The control panel shall be fully wired and factory tested before dispatch. The Control panel shall contain at-least the following control for the automatic operation of chilling unit.

i) Compressor capacity control device.

ii) Start/stop push button station for the machine.

iii) Automatic temperature controller for oil temperature and Chilled water temperature controller shall be of PID type.

iv) Start/stop push button station for chilled water pump set.

v) Operation indicating pilot lamps.

vi) Vane opening indicator calibrated in percent (for centrifugal package).

vii) Pressure Gauges for purge unit (for centrifugal package).

The entire control panel shall be factory wired and factory tested before dispatch.

All controls such as fire damper motors, face and bypass damper motors, modulating type thermostat; high/low pressure switches, oil pressure switches, controls for actuating capacity control solenoid valves, thermostatic expansion valves, pilot solenoid valves flow/pressure switches, heater, heating thermostats, humidistat, and all necessary instruments for automatic, regulated and safe operation of the plant shall be included in the scope of supply and installation. All controls shall be suitably interlocked to operate the equipment in their proper sequence.
Flow meters in chilled water and, condenser water lines signal to control panel, temperature and Pressure Gauges in inlet and outlet of cooling water and chilled water shall be provided locally.

All electric motor driven equipments shall be provided with local Start/Stop Pushbutton stations for operational and statutory requirements. Stop push button shall be lockable type.

Vendor shall provide thermowells in- refrigerant circuit so as to enable to take readings for temperature of refrigerant at various places of the circuit during performance testing. Exact locations shall however, be finalised by Owner and vendor mutually during drawing approval stage.

Calibration of all instruments shall be done by Vendor. Pressure gauges shall be provided with bleed and block valves.
3.26 Audio-visual Annunciation Section:

It shall consist of facia type Annunciators having translucent plastic window of 35 mm x 50 mm (min.) size engraved with appropriate function in block letters for each ‘alarm trip point. Annunciators shall be suitable for operation on 24V D.C. and shall have a single alarm buzzer common to all points. Three push buttons ‘for audible alarm acknowledge, reset and test with appropriate name plates shall be provided common to all alarm points. Annunciators shall be solid state type of, reputed make. Annunciators shall operate satisfactorily between 80 and 110% of rated supply voltage.

Annunciators shall be provided for all faults covering at least the followings:-

a) Low oil pressure.
b) Low chilled water flow.
c) Low condenser cooling water flow.
d) Low chilled water temperature
e) Low evaporator pressure.
f) High condenser pressure.
g) Compressor motor overload.
h) Low water level in humidifier tank.
i) Chilled water pump motor over load.
j) Condenser cooling water pump, motor over load,
k) Air handling unit motors overload.
l) Cooling tower fan motors overload.
m) Treated water plump motors overload (in case ~water softening plant is furnished).
n) Crankcase heater / heaters.
o) Open/close position of fire/smoke dampers.
p) Fresh Air fan status.
q) Any other as necessary.

In the event of a fault, the particular window shall glow and the window will remain lighted till the fault is rectified. Minimum 20% spare windows shall be provided on annunciator.

3.27 Motor / Driver rating :

Electrical drivers (Motors) shall have power ratings at least equal to following percentage of rated absorbed power for all equipments :

<table>
<thead>
<tr>
<th>Absorbed power ( in kW )</th>
<th>Motor rating percentage of</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 22</td>
<td>125</td>
</tr>
<tr>
<td>22 - 55</td>
<td>115</td>
</tr>
<tr>
<td>&gt; 55</td>
<td>110</td>
</tr>
</tbody>
</table>

4.0 INSPECTION AND TESTING
Equipment shall be subjected to expediting, inspection and testing at vendor's/sub-vendor's Works by Third Party Inspection agency (TPI) as per NIT COMMERCIAL PART. Vendor shall submit Quality Assurance (QA) plan before commencement of fabrication. Approved QA plan by owner shall form the basis for equipment inspection. **TPI Cost shall be in vendor’s scope.**

For Inspection and Testing at Site, vendor shall comply with the following procedures:

I. All electrical items will be subjected to inspection at any stage. Routine electrical test as per relevant codes. Inspection of Manufacturer's test certificates.

II. Inspection of raw materials to be used for fabrication and assembly and inspection of manufacturer's test certificates.

III. Inspection of welding including welder's qualification as desired by inspection engineer. Inspection of fabricated items.

IV. Pressure testing of pipe fit ups for refrigerant and water services.

V. Pressure testing, leak testing of complete piping network for chilled water/brine, condenser water & refrigerant services.

VI. Vacuumising & gas/oil charging for refrigeration system.

VII. Checking of electrical circuits (Power and control) and checking functioning of controls of refrigerant system and other circuits of air conditioning plant.

VIII. Checking of assemblies for MCC, control panel, local panel (dimensional & functional), annunciation panel etc.

IX. Checking of calibration of controls and instrumentation.

X. Inspection of complete electrical installation at site and clearance from local authorities.

XI. Installation of main equipments like compressor, condenser, chiller, evaporator, AHU etc.

XII. Mechanical run test of AHU.

**NOTE:**

Inspection & testing procedure mentioned above is for general guidance & information of vendor and inspection by purchaser/consultant is not limited to these. Inspection engineer of Purchaser/consultant will have full right to have detailed inspection of vendor shop/works. Co-ordination of inspection agency / purchaser/consultant with his factory/erection site will be sole responsibility of successful LSTK Contractor after placement of order for complete air conditioning plant covered under these specifications.

However, such inspection by Ownerside, shall in no way absolve the vendor of his responsibility.
5.0 PERFORMANCE TESTING AND GUARANTEES:

Performance Testing

Vendor shall give two seasonal tests for (i) summer or monsoon (More stringent of the two) & (ii) winter to determine the equipment capacity and performance of the system in accordance with applicable Standards and as agreed with owner. For chilling package, performance test at site shall be as per ARI Standard based on the available load and cooling water temperature/ambient conditions. Period of each test shall be at least 48 hours or as agreed by Owner and time for each test will be fixed up mutually with the purchaser and/or his authorised representative.

The vendor shall operate, test and adjust all equipment and balance the system.

Following test readings shall be recorded during the performance testing:

<table>
<thead>
<tr>
<th>Test Readings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.Compressor</strong></td>
</tr>
<tr>
<td>Refrigerant gas suction pressure</td>
</tr>
<tr>
<td>Refrigerant gas suction Temperature (°C)</td>
</tr>
<tr>
<td>Refrigerant gas discharge Pressure (kg/cm² g)</td>
</tr>
<tr>
<td>Refrigerant gas discharge Temperature (°C)</td>
</tr>
<tr>
<td>Operating speed (rpm)</td>
</tr>
<tr>
<td>Power consumption at 100% load and at each step of capacity regulation.</td>
</tr>
<tr>
<td><strong>2.Chiller (for chilled water system only)</strong></td>
</tr>
<tr>
<td>Refrigerant liquid temperature at inlet (°C)</td>
</tr>
<tr>
<td>Refrigerant Gas suction pressure (kg/cm² g)</td>
</tr>
<tr>
<td>Refrigerant Gas suction temperature (°C)</td>
</tr>
<tr>
<td>Water flow rate (m³/ hr.)</td>
</tr>
<tr>
<td>Water temperature – entering (°C)</td>
</tr>
<tr>
<td>Water temperature – leaving (°C)</td>
</tr>
<tr>
<td>Water pressure – entering (kg / cm² g)</td>
</tr>
<tr>
<td>Water pressure – leaving (kg / cm² g)</td>
</tr>
<tr>
<td><strong>3.Condenser</strong></td>
</tr>
<tr>
<td>Refrigerant gas temperature at inlet (°C)</td>
</tr>
<tr>
<td>Refrigerant condensing pressure (kg/cm² g)</td>
</tr>
<tr>
<td>Refrigerant liquid temperature at outlet (°C)</td>
</tr>
<tr>
<td>Air / Water flow rate (m³/ hr.)</td>
</tr>
<tr>
<td>Air / Water temperature – entering (°C)</td>
</tr>
<tr>
<td>Air/ Water temperature – leaving (°C)</td>
</tr>
<tr>
<td>Water pressure – entering (kg / cm² g)</td>
</tr>
<tr>
<td>Water pressure – leaving (kg / cm² g)</td>
</tr>
<tr>
<td><strong>4.Water Pump</strong></td>
</tr>
</tbody>
</table>
Flow rate (m³/hr.)
Discharge pressure (kg/cm² g)
Suction pressure (kg/cm² g)
Operating speed (rpm)

5. Air handling unit

Refrigerant liquid temperature at inlet to coil
Air temperature - entering (D.B) (°C)
Air temperature - entering (W.B) (°C)
Air temperature - leaving (D.B) (°C)
Air temperature - leaving (W.B) (°C)

In case of chilled water coils:
Water pressure - entering coil (kg/cm² g)
Water pressure - leaving coil (kg/cm² g)
Water Temperature - entering coil (°C)
Water Temperature - leaving coil (°C)

Velocity of air in various sections of air handling unit.

6. Electric motor

Starting current/ No load current (A)
Motor terminal current (A)
Power factor
Supply voltage (volts)
Kwh for Compressor motors

7. Supply Air Grilles / Diffusers

Air flow rate (m³/hr.)
Air temperature (D.B) (°C)
Air temperature (W.B) (°C)

8. Room conditions

D.B. & W.B., temperature, RH at different points

9. Air handling unit blower

Speed, static/total pressure, outlet velocity and air flow.

Vendor shall bring all required testing instruments at site duly calibrated. Plant shall be formally taken over by owner after witnessing the seasonal performance tests successfully as per terms & condition prescribed in NIT.
Guarantee for Supply and Workmanship (Defect Liability):
LSTK Contractor shall provide guarantee against workmanship, standard performance parameters and materials of their supply as per provision available in NIT. Guarantee shall be provided by LSTK Contractor for their supplied materials/equipments and workmanship. In this period, if contractor's supplied item(s) fails during operation or not meeting standard performance parameters, then LSTK Contractor shall have to replace with new parts/equipments without any additional cost to owner.

6.0 PROTECTION AND PAINTING:

All exposed carbon steel parts to be painted. Non-ferrous materials, austenitic stainless steels, plastic or plastic coated materials, insulated surfaces of equipment and pre-painted items need no painting.
Stainless steel surfaces, both inside and outside, shall be pickled and passivated.
Machined and bearing surfaces shall be protected with varnish.
Painting Specification shall be as per manufacturer standards.
The color of finish coat may be intimated to vendor, after placement of order.

7.0 PACKAGING AND IDENTIFICATION:

All packaging shall be done in such a manner as to reduce the volume. The equipment shall be dismantled into major components, suitable for shipment and shall be properly packed. To provide adequate protection during shipment. All assemblies shall be properly match marked for site erection.
Attachments, spare parts of the equipment and small items shall be packed separately in wooden-cases. Each item shall be appropriately tagged with identification of main equipment, item denomination and reference number of the respective assembly drawing.
Detailed packing list in water-proof envelope shall be inserted in the package together with equipment.
Each equipment shall have an identification plate (made of SS material) giving salient equipment data, make, year of manufacture, equipment number, name of manufacturer etc

8.0 SPARE PARTS REQUIREMENT:

All erection, pre-commissioning & commissioning spares including spares consumed during testing / PGTR till handing over the plant to owner shall be supplied by LSTK Contractor free of cost. Any unused commissioning spares shall be owner’s property.
Mandatory spares shall be supplied by the LSTK contractor as per NIT.
LSTK Contractor to also furnish separate recommended list of 2 years operation & maintenance spare part list along with budgetary offers, valid for 2 years from the date of submission of offer for owner’s consideration.
Recommended spares and their quantities should take into account related factors of equipment reliability, effect of equipment downtime upon production or safety, cost of parts and availability of vendor's service facilities around the proposed location of equipment.
Detail List of special tools & tackles shall be furnished by the LSTK bidder along with the bid and shall be in scope of supply of the LSTK contractor.

9.0 SPECIAL TOOLS & TACKLES:

Vendor shall provide one set of special tools & tackles as a minimum for operation & maintenance along-with HVAC plant.

10.0 TECHNICAL DOCUMENT REQUIREMENTS

Bidder shall furnish design calculations, Heat Load Calculations for all three seasons (Summer, Monsoon & Winter) with Psychrometric plots specifying the design TR capacity, dehumidified air quantity and Monsoon & Winter heating capacity. Any other data over & above that furnished by Owner shall be referred from Handbook of ASHRAE and Climatological Data Book.

Bidder has to submit all Equipment list with power consumption, GA, Plant layout, Cross sectional drg, technical Drawings of all equipment, Data Sheets, specifications, catalogues, O&M Manual, QAP/ITP, pamphlets and other documents of all equipments in AC plant with their installation and operation & trouble shooting manuals. Bidder has to provide training to purchaser’s engineers / operation team for the operation and maintenance of the entire plant as mutually agreed with Owner.

11.0 ENGINEERING RESPONSIBILITY OF THE SYSTEM:

The responsibility of complete system design, manufacturing, erection, working and safety will solely be responsibility of the LSTK Contractor for the parameters as mentioned in the tender document and this philosophy. The system after commissioning shall be offered to owner for PGTR with mutually agreed period/ duration. Thereafter, Owner will monitor the performance for standard designed parameters for the period agreed with owner. In case, during this period, performance is not found satisfactory and rectification / replacement, design improvement or any other change as felt necessary, will be made by the LSTK Contractor at no extra cost. Though, these improvements can only be done after getting the approval from the owner.

Contractor shall provide supervision services from OEM (original equipment manufacturer) during erection, commissioning and PGTR of the system.
### APPENDIX-1

**INSULATION MATERIAL AND THICKNESS**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Application</th>
<th>Insulation Material</th>
<th>From</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Supply / Return air duct</td>
<td>Resin bonded Fiber glass / equivalent Slab / Roll</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Outdoor Exposed supply / return duct</td>
<td>Resin bonded Fiber glass / equivalent Slab / Roll</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Refrigeration Piping</td>
<td>Polyurethane or Phenolic Foam or, Polysicocynurette</td>
<td>Pipe Section</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>Chiller</td>
<td>-Do-</td>
<td>Slab</td>
<td>60</td>
</tr>
<tr>
<td>5</td>
<td>Chilled water pumps</td>
<td>-Do-</td>
<td>Slab</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>Expansion tank &amp; associated piping</td>
<td>-Do-</td>
<td>Slab</td>
<td>30</td>
</tr>
<tr>
<td>7</td>
<td>Chilled eater piping, valve, specialties</td>
<td>-Do-</td>
<td>Pipe Section</td>
<td>40</td>
</tr>
<tr>
<td>8</td>
<td>AHU Drain pipe</td>
<td>-Do-</td>
<td>Pipe Section</td>
<td>15</td>
</tr>
<tr>
<td>9</td>
<td>AHU Drain pan, coil &amp; blower section</td>
<td>-Do-</td>
<td>Slab</td>
<td>15</td>
</tr>
<tr>
<td>10</td>
<td>Acoustic treatment</td>
<td>Resin bonded Fiber glass / equivalent Slab/ Roll</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Pan Humidifier</td>
<td>Resin bonded Fiberglass</td>
<td>Slab</td>
<td>75</td>
</tr>
<tr>
<td>12</td>
<td>Hot Water / Steam piping</td>
<td>Resin bonded Fiberglass</td>
<td>Pipe Section  / Roll</td>
<td>75</td>
</tr>
</tbody>
</table>
Section-VI- 5.3.7

DESIGN PHILOSOPHY – BOILER

PLANT : STEAM GENERATION PLANT

PROJECT : INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA
<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>DESCRIPTION</th>
<th>SHEET NUMBER</th>
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<tr>
<td>1.0</td>
<td>General</td>
<td>4</td>
</tr>
<tr>
<td>2.0</td>
<td>Scope</td>
<td>4</td>
</tr>
<tr>
<td>3.0</td>
<td>Codes &amp; standards</td>
<td>7</td>
</tr>
<tr>
<td>4.0</td>
<td>Safety</td>
<td>8</td>
</tr>
<tr>
<td>5.0</td>
<td>Equipment Fabrication</td>
<td>9</td>
</tr>
<tr>
<td>6.0</td>
<td>Material of Construction</td>
<td>10</td>
</tr>
<tr>
<td>7.0</td>
<td>Quality Assurance &amp; Control</td>
<td>10</td>
</tr>
<tr>
<td>8.0</td>
<td>Equipment Design Basis</td>
<td>11</td>
</tr>
<tr>
<td>9.0</td>
<td>Specification For Boiler</td>
<td>12</td>
</tr>
<tr>
<td>10.0</td>
<td>Boiler Design &amp; Construction</td>
<td>14</td>
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<tr>
<td>11.0</td>
<td>Furnace</td>
<td>15</td>
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<tr>
<td>12.0</td>
<td>Furnace Lining</td>
<td>16</td>
</tr>
<tr>
<td>13.0</td>
<td>Furnace Openings</td>
<td>16</td>
</tr>
<tr>
<td>14.0</td>
<td>Ducting and Dampers</td>
<td>17</td>
</tr>
<tr>
<td>15.0</td>
<td>Structural steel, Platforms, Walkways, Stairs etc.</td>
<td>18</td>
</tr>
<tr>
<td>16.0</td>
<td>Draft System</td>
<td>19</td>
</tr>
<tr>
<td>17.0</td>
<td>Air Heater</td>
<td>19</td>
</tr>
<tr>
<td>18.0</td>
<td>Economiser</td>
<td>20</td>
</tr>
<tr>
<td>19.0</td>
<td>Superheater</td>
<td>20</td>
</tr>
<tr>
<td>20.0</td>
<td>Steam Drum</td>
<td>21</td>
</tr>
<tr>
<td>21.0</td>
<td>Blowdown Vessels</td>
<td>23</td>
</tr>
<tr>
<td>22.0</td>
<td>Soot Blower Controls &amp; Piping</td>
<td>23</td>
</tr>
<tr>
<td>23.0</td>
<td>Burners</td>
<td>24</td>
</tr>
<tr>
<td>24.0</td>
<td>Stack</td>
<td>24</td>
</tr>
<tr>
<td>25.0</td>
<td>Lime Handing System</td>
<td>24</td>
</tr>
<tr>
<td>26.0</td>
<td>Steam Generator Enclosure</td>
<td>25</td>
</tr>
<tr>
<td>27.0</td>
<td>E.S.P.</td>
<td>25</td>
</tr>
<tr>
<td>28.0</td>
<td>Brickwork, Insulation and Casing</td>
<td>36</td>
</tr>
<tr>
<td>29.0</td>
<td>Electrical Equipment</td>
<td>37</td>
</tr>
<tr>
<td>30.0</td>
<td>Acid Cleaning</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>31.0</td>
<td>Inspection and Testing</td>
<td>38</td>
</tr>
<tr>
<td>32.0</td>
<td>Fire proofing</td>
<td>38</td>
</tr>
<tr>
<td>33.0</td>
<td>Painting, Marking &amp; Shipping</td>
<td>39</td>
</tr>
<tr>
<td>34.0</td>
<td>Spares</td>
<td>39</td>
</tr>
<tr>
<td>35.0</td>
<td>Documentation Schedule</td>
<td>39</td>
</tr>
</tbody>
</table>
1.0 GENERAL

This document covers minimum requirements for design, engineering, manufacture & assembly, inspection, erection, testing, commissioning and performance testing of coal fired PF/CFBC steam generators and auxiliaries (with 2W+1S configuration) including FGD/SCR/SNCR (as required) to meet statutory requirements to well established engineering practices, safety codes and other relevant codes and standards for the Steam Generation Plant for TFL Fertilizer Complex at Talcher, Angul, Odisha.

The overall design, layout and disposition of equipment, system set shall provide a clean layout arrangement with adequate access/space for O&M and safety considerations.

Items though not specifically mentioned but needed to complete the equipment and systems to meet the intent of specification, shall be deemed to be included in the scope of work of Contractor. The scope of supply and services for each steam generating unit shall necessarily include all items and will not be limited to this specification only.

2.0 SCOPE

2.1 The complete design, material of construction/fabrication (shop/site as applicable), inspection, testing, painting, supply, transportation etc. at project site for Steam Generators shall be in scope of LSTK Contractor. All materials shall conform to the specifications, drawings and internationally accepted codes / standards duly accepted by the Owner. In addition, all statutory rules & regulations shall also be complied with.

2.2 LSTK Contractor shall consider the interfaces with other engineering disciplines w.r.t.

- Piping Layout/Location Drawings
- Civil / Structural Drawings
- P & ID's
- Materials
- 3D PDS/PDMS Model for Piping and Equipment Layout
- Hazardous Area Classification

2.3 Design philosophy of other disciplines mentioned below shall be observed and shall be relevant to the extent applicable.

- Civil/Structural Design Criteria
- Piping Design Criteria
- Process Design Criteria
- Electrical and Instrumentation Design Criteria
- Material Handling Design Criteria

2.4 Each steam generator shall consist of:

2.4.1 Boiler drum/s with all internals and fittings.

2.4.2 Complete water cooled welded water wall system, evaporation system, with all associated piping, headers etc.
2.4.3 Complete circulation systems, including all connecting piping, headers, suspension/supports etc.

2.4.4 Complete superheater system including superheater coils, all headers and connecting pipes etc.

2.4.5 De-superheater systems complete, including spray control stations, as required.

2.4.6 Economizer system, including all headers and connecting pipes, casing, supports etc.

2.4.7 Complete boiler integral piping’s, valves and fittings, drains vents, safety valve exhaust piping, startup vent with silencer, blow down systems (both IBD & CBD) sampling systems etc; Pressure reducing stations and piping, for soot blowers. Piping upto turbine ESV inlet and associated instruments.

2.4.8 Tubular air-heater system completes, including casing, structural steel supports etc.

2.4.9 Spray water piping and tapping point upto de-superheater.

2.4.10 Fuel bunkers including complete, platforms, bunker top cover flooring materials, bunker inside lining material, isolating gates etc. complete. Necessary poking holes including level sensor, Load cell for weight measurement, vibro-system in hoppers.

2.4.11 Fuel down take chute system connecting bunker outlet isolating gate to Feeders, and from feeders to the fluid bed as applicable with all auxiliaries.

2.4.12 One sand silo/bunker system for boiler, including support steel, rotary air lock feeder for flow control, discharge piping system to combustor.

2.4.13 One Limestone silo/bunker system for boiler, If required, including support steel, rotary air lock feeder for flow control, discharge piping system to combustor.

2.4.14 Fluidized bed combustor unit (if required) proper including all related fuel feed systems, windbox, air distribution and control systems, water cooled floor distribution panels and nozzles (all as applicable), thermal expansion systems, ash removal/drainage systems, along with required supporting steel etc.

2.4.15 Complete and required number of ash coolers with related valves/gates, piping and control system for automatic operation.

2.4.16 Complete system of buck stays and tie bars for the boiler.

2.4.17 Structural steel, platforms, stairway set for the main boilers, auxiliaries, bunkers and fuel feed system ducting, piping and other systems complete.

2.4.18 Complete roof and side cladding along with structures for protection against rain and other climatic conditions for operating floors, drum floors and other floor levels including gutter and rain water down pipes.

2.4.19 Complete foundation bolts, anchor channels, sleeves, packer plates, soleplates and any other associated material for all supports and equipment.

2.4.20 All supports, suspension system etc for all pressure part systems, components etc; Non pressure parts, auxiliaries, piping etc all within the terminal points specified.
2.4.21 Common base plates, soleplates, frame foundation material complete for all driven and drive equipment, systems.

2.4.22 Support structures covering materials and supports for all fans and drives; as well as other critical equipment/system.

2.4.23 All miscellaneous structural steel required, including handling arrangements for all heavy equipment for maintenance (including all fan impellers, drive motors etc).

2.4.24 Draft system (for each boiler unit) comprising:

2.4.24.1 2x60% Primary air fan, control mechanism and suction hood and silencer.
2.4.24.2 2x60% Secondary air fan, control mechanism and suction hood and silencer.
2.4.24.3 2x60% Induced draft fans, control mechanism.
2.4.24.4 2X100% capacity sealpot blowers (1W+1S)

2.4.25 Complete air ducting, gas ducting upto ESP inlet, ESP outlet to ID fans, ID fans to stack all with required dampers and actuators, expansion joints, steelwork, supports, hoppers, thermal insulation with cladding etc.

2.4.26 Outer casing for the main boiler shall be of suitable material as per OEM recommendation.

2.4.27 Complete requirements of refractory (Normal and special grade for all high temperature locations/equipment system and with special fixing materials etc. complete), lining and insulation material; fixing material for all equipment and systems.

2.4.28 Boiler mountings including access doors/ inspection doors peep holes.

2.4.29 Access platforms and convenient operating gears for manually operated dampers, valves etc.

2.4.30 Bidder to note that Indian Coal shall be used as fuel source, hence worst coal firing shall considered for providing soot Blowers(if required).

2.4.31 Complete piping, valves and fittings as required.

2.4.32 Intermittent blow down tank and continuous blow down tank with complete piping system including drain headers, drain, vent piping and controls.

2.4.33 All required piping, valves, fittings, controls, instruments, supports, steel works, suspension systems, insulation and outer casing etc. for the various equipment/ systems within the terminal points specified.

2.4.34 Chimney steel wall frame unit complete including embedments and fasteners for connecting flue gas duct.

2.4.35 Commissioning spares.

2.4.36 Mandatory /Insurance spares and Special maintenance tools and tackles.

2.4.37 Two (2) years O&M spares:

- LSTK contractor shall submit/provide recommended 2 years O&M spares (other than Mandatory spares) list with budgetary offers valid for 2 years from the date of submission of offer for Owners consideration.
• Supply of Mandatory Spares/Insurance spares- to be included in the scope

2.4.38 First fill of lubricants & chemicals:
First fill of oil, lubricants, chemicals and all consumables during Pre-Commissioning, Commissioning, Sustained Load Test Run and Guarantee Test Run (GTR) till handing over to Owner.

2.4.39 Paints and painting of all components at shop, before dispatch and at site on completion of erection.

2.4.40 Boiler pressure parts alkali boil out cleaning system at site including all required materials, chemicals etc.

2.4.41 Chemical dosing systems

2.4.42 N2 blanketing system for Boiler preservation with manifold to be installed and terminated in one terminal point at ground level near Boiler area. The Nitrogen blanketing equipment including adequate number nitrogen cylinders shall be in Bidder’s scope.

2.4.43 To avoid flow problems in Limestone Bunker, necessary system such as Hammer/air cannon/Proven methodology shall be considered.

2.4.44 Any other Special Equipment and System required for the PF/CFBC boiler system proposed by bidder.

3.0 CODES AND STANDARDS

3.1 All equipment, systems and work covered under this specification shall comply with all latest statutes, regulations and safety codes, as applicable in the location where the equipment will be installed.

3.2 All the parts of the steam generator including pressure parts, vessels, piping, valves including safety valves and fittings shall meet or exceed all the requirements of latest editions of Indian Boiler Regulations (IBR).

3.3 Any other standards acceptable to IBR can also be considered, provided the requirements of those standards are equivalent or exceed the IBR requirements.

3.4 Wherever the specification stipulates requirements in addition to those specified in IBR, the same shall also be complied by the Contractor.

3.5 In cases where IBR does not govern, other international standards established to be equivalent or superior to the codes and standards specified, are also acceptable. However, in the event of any conflict between the requirements of the equivalent Codes and standards, and the requirements of the Indian standards/ regulations, the latter shall govern, unless, specified otherwise in the specification.

3.6 It shall be responsibility of the Contractor to obtain the necessary approvals of Inspection Authority/ Chief Inspector of Boilers on behalf of the Owner, as may be required for designing and design calculations, manufacturing and erection procedure, Testing etc. as called for under the IBR. It includes Registration of boiler erection and inspection fees to be paid, obtaining certificates to use the boiler, steam testing and obtaining Register no including Co-ordination with Boiler inspector ate, arrangement of visit to site by Director of Boiler ,Deputy Director of boiler, etc,. All such documentation submitted to statutory authorities shall also be submitted to the Owner for his review. It shall also be the...
responsibility of the Contractor to furnish the requisite documentation as required by the Owner for getting the Steam Generator registered under IBR.

3.7 Codes/Standards for integral piping and valve shall be ANSI B16.34 and ANSI B16.25 (valves), ANSI B31.1 (for piping) and ANSI B16.5 (flanges), ASTM-A-335, ASTM-A-106, SA210 and SA213 (High Pressure/ temperature piping and tubing). Wherever definite design stipulations are not available in the IBR, the ASME Section- I and IBR (for Steam Generator Integral Piping) shall be referred.

3.8 The steel structures and foundations shall be designed for earthquake conditions as per IS-1893 and wind loads as specified in IS-875.

3.9 Boiler efficiency shall be calculated based on ASME PTC-4.0 (Energy Balance method).

3.10 The work falling under the purview of Indian Boiler Regulations (IBR) shall completely meet or exceed all the requirements of the latest edition of IBR. Any other standard acceptable to IBR can also be considered, provided the requirements of that standard are equivalent or exceed IBR requirement.

3.11 Order of Precedence of Documents

In case of any conflict between standards, codes and specifications, the stringent of all shall be followed.

Where conflict occurs, the order of precedence shall be as below:
Local Statutory Regulations like IBR etc.;
This specification;
OEM’s drawings & specifications;
Other Technical Specifications or Design Specifications or Technical Standards enclosed, if any.

3.12 Regulations

All items of equipment shall comply with the latest Indian Boiler Regulations and stipulations of Inspectorate of Factories, Chief Electrical Inspectorate and other statutory bodies as per the requirement. Wherever required, the LSTK Contractor has to obtain the necessary approvals from statutory authorities and other concerned agencies. All cost, on these accounts shall be borne by the LSTK Contractor. Static and Mobile Pressure Vessel (SMPV) rules as applicable shall also be complied with.

3.13 Site Conditions

3.13.1 Climatic and other site conditions as defined elsewhere in ITB.

3.14 Design of equipment inside the Steam Generation plant complex shall be in accordance with the OEM’s data sheets and specifications.

4.0 SAFETY

4.1 Safety standards and features which are inherent in the specific mechanical equipment design codes, standards and regulations are applicable to this criterion. Job Hazard and Operability [HAZOP] as per OHSAS-18001 & Indian Factory Act shall be done during design stage the equipment.
4.2 Safety features to be incorporated into the design include, but are not limited to, the following features for equipment:

- Ladder cages
- Safety chain across platform access
- Step-off platforms with Hand Railing, where necessary
- Platform grating with adequate thickness
- Toe plates

5.0 EQUIPMENT FABRICATION

5.1 Headers shall be manufactured by seamless process. Headers shall be provided with access arrangements to allow full internal visual inspection and cleaning.

5.2 Membrane panel construction shall be either made by a fusion-welded fin or of integral fin type. Resistance welded fin construction will not be allowed unless appropriate satisfactory reference experience can be demonstrated.

5.3 Tests for the qualification/approval of welding procedures and welders shall be carried out as per the Indian Boiler Regulation/applicable ASME code. Where no standard is specified, an internationally recognized standard shall be used subject to the Owner/PMC approval.

5.4 Permanent backing rings shall not be used.

5.5 Oxy-acetylene welding shall not be used.

5.6 Equipment design shall be based on maximizing shop fabrication and assembly where deemed practical. Fabrication shall not begin until the Contractor has received written approval for the drawings/documents from Owner.

5.7 The LSTK Contractor shall comply in all respects with the provision of the applicable codes / standards and specification during fabrication.

5.8 Impact test, when required as per code and specifications, shall be carried out on parent metal, weld etc.

5.9 Production Control coupons, when required as per code and specifications, shall be subjected to all tests like impact test etc., in addition to mechanical test as required. In case of heat treated equipment test coupons shall be given similar heat treatment as for the equipment.

5.10 Due provisions must be kept for venting out entrapped gases during welding of pads, flanges and liner plates etc.

5.11 In case of equipment involving site assembly/fabrication the entire site job including loading & unloading at site, fabrication, radiography, heat treatment, Inspection & testing etc. shall be included in the scope of supply.

5.12 Flange facing and thread connection shall be protected against oxidation during heat treatment.
5.13 Nozzles and manholes shall be joined to the shell and to their reinforcements with full penetration welds. All nozzles shall be set-in type, unless otherwise specifically accepted.

6.0 MATERIAL OF CONSTRUCTION

6.1 In selecting material of construction of various equipment, the contractor shall pay particular attention to the atmospheric conditions existing at the site and the nature of material/fluid handled. Moreover materials offered shall be consistent with the proven units under specified service conditions. All materials shall be new and shall be of quality most suited to the proposed application.

All parts, which could deteriorate or corrode under the influence of site/working conditions, shall be suitably and effectively protected to minimize such effects. In as far as possible, materials shall be in accordance with national or international standard specifications and shall be used in accordance with national or international codes of practice. Where such standards or codes of practice are not available, sufficient information shall be provided to allow the engineer to assess the suitability of the material for the particular application.

6.2 The minimum requirement of the materials shall be as per the plant equipment metallurgy covered under Process Design Specifications / guidelines. However, superior materials as per the recommendation of OEM's given in their Specifications shall be selected which shall be indicated in the Bid by the LSTK Contractor.

6.3 All materials, whatsoever, required to complete the supplies shall be procured by LSTK Contractor and all such materials shall be covered with due identifiable material test certificate.

7.0 QUALITY ASSURANCE & CONTROL

7.1 The quality assurance shall be as per the approved procedures, test methods & facilities to be developed by the LSTK Contractor to ensure that the supplied equipment shall be of highest quality. The quality control shall mean that all the tests, measurements, checks & calibration which are to be carried out may be compared with the actual specified characteristics of the equipments/unit/system.

7.2 Quality Assurance (QA) shall mean the organizational set up, procedures as well as test methods and facilities developed by LSTK Contractor in order to assure that Equipment leaving LSTK Contractor’s shop are of the highest possible quality i.e. either equal to or better than the requirement specified.

7.3 Quality Control (QC), shall mean all the tests, measurement, checks and calibration which are to be carried out in LSTK Contractor’s shop in order to compare the actual characteristics of the equipment/unit/system with the specified ones, along with furnishing of the relevant documentation (certificates(records) containing the data or result of these activities.

7.4 LSTK Contractor shall submit a comprehensive description (manual) of QA/QC measures contemplated by him for implementation with regard to this specification. It is contractual obligation of the LSTK Contractor to develop and implement adequate QA/QC systems.

7.5 QA/QC system shall cover all products and services required for the equipment as per scope of work including job sub contracted by the LSTK Contractor.
8.0 EQUIPMENT DESIGN BASIS

8.1 General

8.1.1 Design conditions for equipments shall be in accordance with the OEM’s data sheets/specifications for TFL steam generation plant duly approved by PMC.

8.1.2 Wind forces shall be increased by 20% to cater for the effect of piping system, platforms and ladders etc. Vertical vessels with height/diameter ratio equal to or greater than 10 shall be analyzed for vibration due to vortex shedding when critical wind speed does not exceed 30m/s. Design of equipments shall also consider very high velocity cyclone wind speed.

8.1.3 Forces and moments acting on nozzles shall be considered in the equipment design. The exact forces & moments shall be indicated after piping layout which shall be considered by equipment supplier with out any commercial implication to Owner.

8.1.4 All Carbon Steel (CS) and Low-Alloy Steel (LAS) Steam Drum shall have 3 mm corrosion allowance unless specified otherwise. No corrosion allowance shall be considered for SS. The recommendation of OEM shall be adopted for construction, if found more stringent. For heat transfer area tubes, corrosion allowance shall as per code.

8.1.5 Design of supports and anchor bolts considering soil and important factors shall be performed for compressive and tensile loading.

8.1.6 Lifting lug shall be designed with shock factor 2 (minimum).

8.1.7 The requisite no. of hydraulic stud-tensioner device with necessary adopters/insertions based on varying sizes of studs shall be considered by Contractor as per mechanical design of the equipment.

8.1.8 Local stress analysis around nozzles and other external attachments shall be calculated according to WRC Bulletin 107 and 297.

8.1.9 Manhole cover with weight over 20 kg shall be supported by davit.

8.1.10 Nozzle for drain & vent shall be trimmed flush with inside surface of vessel. Other nozzle may extend inward within limits for welding.

8.2 Design Loads

Design loads shall comply with the requirements of IS: 875 and IS:1893 as minimum. The following types of loads in addition to Dead Loads (DL) shall be considered in special type of loading depending upon the type of equipment and operating conditions is likely to be imposed, the same shall also be considered.

8.2.1 Live loads

The minimum loading shall be 300 kg/m2.

For operating Platforms, the loading shall be 500 kg/m2.

8.2.2 Equipment loads
Equipment causing heavy concentrated loads shall be considered separately. The loading considered for tanks and piping shall include hydraulic test loads.

8.2.3 Wind loads

Wind Loads shall be estimated as per the design philosophy - Civil.

8.2.4 Seismic loads

Seismic Loads shall be estimated as per the design philosophy - Civil.

8.2.5 Thermal loads

Thermal loads as per the operating conditions and support conditions shall be considered.

8.2.6 Load combinations

A judicious combination of load keeping in view of the probability of their acting together, their disposition in relation to other loads and severity of stresses caused by combinations of various loads shall be considered for the design. Wind load and earthquake shall be assumed not to act simultaneously. The bidder shall spell out the load combinations considered separately.

9.0 SPECIFICATION FOR BOILER

9.1 General

9.1.1 The steam generators (PF/CFBC) shall be of semi-outdoor type and designed and constructed according to the latest version of Indian Boiler Regulation and Acts. The materials and the design of pressure parts including pipes shall be approved by Chief Inspector of Boilers' and shall be inspected and certified by the inspecting authorities approved by Indian Boiler Regulation during fabrication and construction. The Contractor shall submit to the Owner and Chief Inspector of Boilers' the calculations of all pressure parts including pipes showing that the requirements of Codes and Acts have been fulfilled.

9.1.2 The boiler shall be of natural circulation drainable type and shall be so designed that at all boiler loads, an adequate water circulation takes place throughout all sections of water walls and there is no starvation in any section.

9.1.3 Continuous blowdown shall be done to limit total dissolved solids (TDS) and silica in boiler water.

9.1.4 To provide adequate strength against pressure, flow vibration and shock, tube banks of all sections shall be adequately supported by tube support plates with intermediate baffles to minimize flow induced vibrations.

9.1.5 Nozzle Connections:

9.1.5.1 Drums and headers shall be fitted with machined holes for inserting tube stubs and weld end nozzles. All nozzles shall be welded to the drums and headers in the shop and designed to extend through insulation where applied. All drums and headers shall be located outside the gas path. The Contractor shall provide sufficient nozzles for each of the following and as required to meet IBR stipulations:

   a) Safety valve
b) Steam gauges
c) Feed water piping
d) Blowdown piping
e) Vent valves
f) Independent water column at both ends
g) Steam gauge test connection
h) Chemical feed piping
i) Boiler blow off piping
j) Feed water regulator controller
k) Drum level indicator
l) Steam sampling/water sampling to draw representative samples from drum
m) Acid cleaning and hydro test connection
n) Steam outlets
o) Air release etc.
p) Thermocouple
q) Purge Gas Connection
r) Boiler fill connection

9.1.5.2 The contractor shall be agreeable to provide at no extra cost, any additional nozzles that the owner may consider necessary for proper operation, if so requested prior to commencement of manufacture.

9.1.6 Drums shall be provided with manholes in each end to permit access to the drum interior.

9.1.7 The Steam Generation plant shall be capable of delivering net sent out power after deduction of internal consumption for it's auxiliaries and BOPs.

9.1.8 There shall be dedicated Steam Generators for process steam (a) for supplying HP Process Steam at required parameters (b) for superheating low temperature HP Process Steam from Ammonia plant to the required temperature and returning back for Process consumption. Steam parameters shall be as per OEMs specifications of main process plants.

9.1.9 In addition to above boilers, there shall be a Standby Common Boiler for Process Steam Generation. Capacities of all the boilers shall be as per process design philosophy (Section-1 & Section-4.0) enclosed with ITB.

9.1.10 The steam generator shall be either Pulverised Fuel (PF) or Circulating Fluidized Bed Combustion (CFBC) type. Basically the boiler shall be a radiant furnace, non-reheat, Single Drum, natural circulation, semi-outdoor type with stage superheater(s). The boiler shall be designed with water cooled membrane / fin welded walls and the refractory work shall be kept to the barest minimum possible.

9.1.11 No header shall be placed in the flue gas path. All headers in the boiler shall have flat end covers. A minimum of two handholes for the purpose of cleaning and inspection shall be provided, for each of the headers, either on the end covers or on the body of the headers.

9.1.12 The drive motor rating for all pumps and fans shall be as per datasheet of the respective driven equipment.

9.1.13 The boiler shall be top supported with adequate provisions for the thermal expansion of the boiler in all directions.
9.1.14 Steam generator shall be designed for the complete range of fuel (Indian Coal) specified elsewhere in ITB.

9.1.15 The steam generator shall be designed to generate rated capacity of superheated steam as mentioned in Process ITB.

9.1.16 The steam generator shall be designed for balanced/induced draft operation as per type of Boiler.

9.1.17 The complete pressure part system of boiler, piping & valves, design shall fully comply with the Indian Boiler Regulations (IBR).

9.1.18 The requirements specified are the minimum design and sizing requirements for the steam generator and its auxiliaries. Contractor's utilization of various values and requirements indicated in this specification shall in no way relieve the Contractor of his responsibilities to meet all guarantee requirements or of providing completely safe and reliable operating equipments/systems.

9.1.19 The specified requirements shall be complied for the most stringent conditions resulting either from the range of coals specified or from the range of operating conditions specified or from both occurring simultaneously, unless otherwise specifically mentioned by the Owner.

9.1.20 Steam Generator and its auxiliaries shall be sized for 60% to 100% BMCR condition for single stream operation.

9.1.21 Typical characteristics of specified range of coals/limestone such as high abrasive, slow burning, high ash resistivity etc shall be given due consideration while designing Steam generator and its auxiliaries.

9.1.22 The design of Steam Generator shall comply with the design requirements set out in this section and also meet the requirements specified in specified Design Data.

10.0 BOILER DESIGN & CONSTRUCTION

The unit shall be semi-outdoor type and designed and constructed according to the latest version of International Codes & Acts. The material and the design of pressure parts shall be approved by Statutory Authorities (Indian boiler regulations) and shall be inspected and certified by IBR authorities during fabrication and construction. The contractor shall submit to the Owner and the Inspection Authorities, the calculations of all pressure parts showing that the requirements of Code & Acts have been fulfilled.

The boiler shall be of natural circulation type and shall be so designed that at all boiler loads, an adequate water circulation takes place throughout all sections of water-walls and there is no starvation in any section.

The efficiency of the unit shall be minimum 85%, based on gross calorific value of coal. Boiler of higher efficiency may be offered. The PG test shall be done by either direct method and or relevant PTC code.

The gas velocities shall be low, bearing in mind the ash content of the fuel and the gas passages designed to ensure a smooth flow without any abrupt change in direction. Continuous blowdown shall be regulated, to limit the total solids in the concentrated boiler.
11.0 FURNACE

Furnace design shall be compatible to the latest proven technical advances/upgrades in the relevant PC/CFBC technology.

11.1 Furnace shall have maximum of water-cooled surface with minimum of refractory being exposed to heat. It shall be designed to ensure efficient and complete fuel combustion with no accumulation of slag and no impingement of flame on its parts. Water wall shall be made of Hot finished seamless steel tubes.

11.2 Furnace cannot be free from refractory with the fluidisation of bed material having high erosion potential. The water wall tubes will be adequately protected in the fluidisation zone, if applicable. The height of refractory lining will be as per the designer and the water wall tubes at the interface point where the refractory line ends to be suitably protected with some special metal spray or through any other design standard as per vendor. Besides the refractory will be preferable at the cyclone entry point, if applicable. These are the main erosion prone areas in the combustor.

11.3 The furnace shall be fed with coal from a coal bunker of suitable capacity, the supply & installation of which shall be in the scope of LSTK bidder.

11.4 The furnace shall be designed with sufficient volume, to provide for complete and efficient combustion of fuel. There shall be no flame impingement on any part of the furnace and no accumulation of slag on the walls.

11.5 The furnace shall be provided with the maximum water cooled surface (membrane water walls). The furnace shall be enclosed by water walls with welded membrane type construction of seamless steel tubes of proved composition. The side walls, front walls, roof and floor tubes shall be site assembled into panels of welded construction. Minimum allowance of 0.6 mm over and above the calculated thickness as per ASME/International codes shall be provided for entire water wall.

11.6 The furnace shall be provided with protective measures such that under all expected operating conditions, the pressure condition in the furnace does not exceed the furnace safe design limit. Contractor shall indicate the pressure withstanding capacity of the furnace and furnish the details of co-ordinated operation of system components like fans, damper, etc., to establish the above requirement.

11.7 Entire furnace shall be suspended from a suitable supporting structure, allowing free expansion in downward direction.

11.8 Adequate number of access and observation openings/doors shall be provided in furnace, superheaters. Doors shall be hinged & air tight and meet all safety requirements and have approach platforms. Access doors on water walls will preferably be from both sides for approach to superheater, economiser areas, etc.

12.0 FURNACE LINING

12.1 Floors, walls, and arches shall be lined internally by refractory and/or insulation materials so that the outside casing temperature shall not exceed as per Process Design philosophy. Modular Refractory Material (Ceramic Blankets) shall be used for walls and arch for
maximum energy conservation. Brick Insulation can be used for Floor of the furnace.

12.2 Walls shall be sectionally supported from furnace casing and arch-suspended from arch steel. Bridge walls not supporting tubes may be of self-supporting solid brick.

12.3 Material specifications and test methods of refractory should conform to ASTM Standard. However, proprietary goods by qualified manufacturers may be used if specified in the drawings and/or data sheets.

13.0 FURNACE OPENINGS

13.1 Access doors shall be provided at suitable position for internal inspection.

13.2 All doors shall be made of cast iron or structural steel lined with refractory.

13.3 Instruments and Auxiliary Piping Connections

(a) Draft gauge piping connections shall be in the number required by design at the location as per detail engineering.

(b) Flue gas thermocouple connections shall be provided at least for each radiant section and exit of convection section.

(c) Thermo well to measure process temperatures shall be provided according to process requirement.

(d) Flue gas sampling connections shall be at least at two places at two opposite ends/intermediate places (if possible) at the exit of the convection section wherever necessary for measurement and monitoring.

14.0 DUCTING AND DAMPERS

14.1 All flue gas and air ducts shall be fabricated from carbon steel sheets. Ducts shall be properly reinforced and of welded construction for gas tightness. Suitable supports, expansion joints and access doors shall be provided in all ducts wherever required. Hangers for ducts and connections to the supporting steel for ducts shall be included. Duct shall have bolted connections to equipment and access door. Ducts shall be insulated.

14.2 All dampers shall be of multi blade type having frames made of heavy channel sections. Dampers shall be designed to prevent sticking and leakage and to allow for heavy erosion.

14.3 All the hot gas ducts shall be insulated & cladded so that skin temperature shall not be more than 20 degree C form the ambient temperature.

14.4 All critical dampers including at the suction and discharge of the draft fans will be either motorised or pneumatic. Pneumatic ones will be preferred.

14.5 The material of flue gas duct shall resist corrosion due to condensation of SO2 in flue gas, or suitable lining to be provided to prevent corrosion.

14.6 The Ducts and Duct work components shall be as per the detailed specifications and drawings prepared by the Contractor. This specification indicates minimum
requirements in order to ensure satisfactory performance for the fluid service under the operating pressure and temperatures. In general, the raw materials used should be of good quality and proven for the intended use.

14.7 All ducts and wind boxes shall be fabricated from steel sheet not less than 5 mm thick (with zero tolerance for min. thickness).

14.8 Ducts shall be properly reinforced and of welded construction for gas and air tightness. The inlet air ducting to the FD fans shall contain an aerofoil for air flow measurement and shall be of carbon steel.

14.9 Suitable supports, expansion joints and access doors for cleaning, shall be provided in all ducts, wherever required. Hangers for ducts and connection to the supporting steel for ducts and hoppers shall be included.

14.10 Ducts shall have bolted connections to equipment, expansion joints, access door frames.

14.11 The air duct may contain deflector plates, as necessary, to promote good air distribution.

14.12 Minimum thickness of duct casing plate material shall be minimum 5 mm, unless found to be of higher thickness as per design calculations.

14.13 Following material shall be used unless otherwise specified elsewhere in ITB:

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>ASTM A 240</td>
</tr>
<tr>
<td>Structures for Support</td>
<td>Confirming to IS</td>
</tr>
</tbody>
</table>

14.14 The Contractor may install shop fabricated ducts in modular design also.

14.15 Reinforcement rings should be provided for ducts of rectangular cross section and round ducts of large sizes wherever negative operating pressures are indicated.

14.16 Contractor shall provide fastening cleats on ducts where insulation is required to be provided. On C.S. ducts, cleats should be of C.S. and on S.S. ducts, S.S. pads shall be welded to duct and C.S. cleats on pads shall be welded. Alternatively, the entire cleat may be provided of S.S. material for S.S. duct. C.S. washers shall be provided for cleats.

14.17 Shot blasting with one coat of primer on carbon steel ducting shall be provided. Further, painting shall be as per specification provided elsewhere in ITB.

14.18 Testing of furnace ducting:

14.18.1 Welded joints and prefabricated components shall be randomly dye penetrant tested.

14.18.2 Pressure testing of the ducting is generally not required. However, TPIA / Owner may use their discretion and direct the vendor to test some of the items, as and where considered necessary.

14.19 Ducting design shall consider besides internal pressure, maximum temperature, dead load, ash load (where applicable), live load, seismic load etc. Further, load factor corresponding to temperature rise shall be taken care in duct design.
14.20 Hot flue ducting system at furnace outlet, if applicable, shall be of special design with material and insulating system of proven type for duty conditions. Special expansion arrangement and supporting system shall be provided. These shall be detailed in the offer. Expansion bellow in flue gas and air duct shall be heavy duty metallic expansion bellows.

14.21 Complete flue ducting from AH outlet to ESP inlet funnel and from ESP outlet onwards to ID fan(s) and from ID fans to stack inlet shall be provided, with required dampers, supports etc. Changes in ESP elevation, location and arrangement of ESP inlet outlet funnel shall be envisaged and connecting gas duct adjusted as required.

14.22 100% Gas tight isolation dampers of motor/pneumatic operated type (make and design to approval) shall be provided to enable maintain equipment, when the unit is on load, e.g.:

- PA fans outlet (isolating, damper)
- SA fans outlet (isolating, damper)
- ID fans inlet and outlet (isolating, damper)

For any other equipment/ system proposed, such requirement shall be provided as a part of the offer.

14.23 The ducting layout shall be such that it does not interfere with the operating personnel movement.

15.0 STRUCTURAL STEEL, PLATFORMS, WALKWAYS, STAIRS ETC.

15.1 The structural design shall be in accordance with Design Philosophy - Civil & Structural Works, provided elsewhere in NIT, unless otherwise specified. Some salient features of structural design are as below:

Structural members shall be designed in accordance with IS (Indian Standard).

15.2 The contractor shall furnish necessary platforms, walkways and stairs to provide access for proper operation and maintenance of all parts of the equipment. Cat ladders shall be avoided. Each major platform shall have double access/exit as required under Factories Act.

15.3 The unit shall be carried on a self-contained steel framework built up from +300 mm level. The shop connections can be welded. Field connections shall be Welded / bolted with high strength bolts.

15.4 All tubes, headers and burners shall be supported from furnace steel framework, independently from the insulation or refractory lining.

15.5 A minimum steel plate thickness of furnace casing shall be 5.0 mm for wall and 6 mm for floor and arch, and those plates shall be suitably stiffened.

15.6 Floor plate of platforms or walkways shall be of Gratings and shall be of 5.0 mm minimum thickness, unless otherwise specified in ITB.

15.7 Roofing and siding, if any, shall be of colour coated metapoly sheet or other suitable weather resistant roofing materials. Roofing shall have arrangement for exhaust/ventilation for hot air exhaust.

15.8 Header boxes shall be constructed of stiffened steel plate with 5.0 mm minimum thickness.
and lines internally with insulation materials.

15.9 Stairway

15.9.1 Minimum vertical headroom clearance shall be 2100 mm and minimum perpendicular clearance shall be 1800 mm unless otherwise specified in ITB.

15.9.2 Maximum vertical run for a single flight of stairway shall be 4000 mm unless otherwise specified in ITB.

15.9.3 Unless otherwise shown in the drawings, stairway shall have a maximum angle of 45 degrees and a preferred rise of 200 mm.

16.0 DRAFT SYSTEM

16.1 The draft system for the boiler shall be suitable of producing a balanced draft with sub-atmospheric pressure conditions in the furnace.

**Induced Draft Fan, Forced Draft Fan and Primary Air Fan** making up the complete draft system for the boiler.

17.0 AIR HEATER

17.1 The contractor shall furnish tubular type or regenerative type of air heater, one for primary air and one for secondary air. Regenerative air heater can be common for both secondary air and primary air. If tubular air heater is offered, one number for each secondary air and primary air shall be offered by vendor.

17.2 The air heater shall be designed for 100% firing of the fuel in the boiler. The sizing shall also consider the exit flue gas temperature limit as per Process Design philosophy.

17.3 The air heater shall be complete with steel casings, access doors, necessary duct hoppers, etc., for complete installation.

17.4 The heater shall be so designed as to permit washing down with water and hopper shall be manufactured with appropriate material to suit operating conditions.

17.5 The air heater shall be designed with flanged connection for the air and gas inlet and outlet ducts. The heating surface shall be proportioned to obtain an optimum flue gas outlet temperature as per required process conditions. Provision shall be made for low load operation to assure a minimum flue gas outlet temperature above the acid dew point.

17.6 The cold end of the air heater tubes shall be made of corrosion resistant material. The last bend shall be made of Corten steel of 1.2 mm thk (Min.). Hot/intermediate end shall be made of carbon steel Min. 0.8 mm thk.

17.7 The layout and arrangement of any of the air heater blocks shall be such that when required the tubes can be removed for replacement, without any major disturbance, to the adjacent equipment or systems.

17.8 The air heater shall be complete with all casing, supporting structures, ducting systems etc. A suitable air or gas bypass ducting system with regulating type damper, of appropriate size shall be provided, for use during plant start-up/part load conditions and to ensure rated temperature to the ESP for its optimum performance.
17.9 The bypass dampers shall be provided for control room operation, equipped with drive unit.

17.10 The AH casing shall have a minimum thickness of 4.0mm. Required access doors, platforms, walkways, etc shall be provided as required. Clear gap between any AH blocks on air/gas side shall not be less than 600mm.

17.11 Bidder shall make provision of space for future installation for heating surface of 10% or two loops, whichever is higher.

17.12 Only metallic hoses shall be used for bearing, cooling/lubrication. Rubber hoses are not acceptable.

17.13 Rotary Air preheater shall be driven by electrical motor with an air motor as stand by unit.

17.14 An air receiver tank of adequate storage capacity to operate air preheater using air motor for 10 minutes (Min.) with no air make up during this period.

17.15 Air preheater rotor stand still sensing device with alarm to control room shall be provided.

18.0 ECONOMISER

18.1 The section shall be of non steaming design with bare tube construction and drainable type and shall be arranged in sections and be provided with all tube elements, headers, connecting tubes, casing and accessories required for complete installation.

18.2 The casing shall be gas tight and provided with access doors for entrance to locations between each sections of the economiser for inspection and easy replacement of tubes. All economiser headers shall be located outside the gas path.

18.3 In the economiser the gap between the banks and between the coils should be such that those can be easily inspected and repaired. The correct pitch between the coils to be ensured and the gap between the coils and casing plate to be kept uniform to prevent formation of any eddy bubbles in flue gas path.

18.4 The economiser shall be provided with all tube elements headers, connecting tubes, casing and accessories required for complete installation. Uniform flow and heat distribution shall be ensured throughout. The economiser shall be of seamless bare tube, drainable type complete with inlet/outlet headers. The tubes, headers and all connecting piping shall be of seamless type.

18.5 Tube spacing in economiser shall be 0.8 mm Min.

18.6 Proper draining arrangement shall be provided for Economiser.

18.7 Material selection and proper design shall receive special attention where water turbulence is caused by change of flow direction leading to erosion / corrosion.

18.8 The casing shall be gas tight and be provided with access doors for entrance to locations between each section of the economiser for inspection and easy replacement of tubes. The ECO casing shall be of minimum 5.0 mm thick plate suitably stiffened/reinforced. Minimum clearance between any two blocks of ECO and or ECO and AH shall be 610 mm.
18.9 Provision for easy removal/replacement of ECO elements shall be taken care, in the design and arrangement. Economizer coils shall be independently supported with separate structure.

18.10 Economiser shall be provided with minimum 3mm thick SS erosion shield for leading tube of economiser.

19.0 SUPERHEATER

19.1 The boiler shall be equipped with suitable drainable/Platina/Pendant type superheaters of sufficient capacity and surface to superheat the steam to the required condition specified as per OEM proven facts. Superheater outlet temperature shall be maintained within the limit specified.

19.2 The superheater shall be designed for maximum accessibility and types so arranged as to permit easy replacement. Superheater shall be convection type seamless bare tube construction. Use of girdling loops not permitted.

19.3 All superheater headers shall be liberally sized and located outside the gas paths.

19.4 Adequate provision shall be made in the design of all superheater tubes, supports, expansion of various components. The tube elements design shall be such that the tubes will provide flexibility to aid in relieving pipe stress.

19.5 A suitable number of permanent thermocouples in observing tube metal temperature during starting up shall be provided.

19.6 Following connections and accessories shall be provided for each header:
Drains : 40 mm minimum size
Vents : 25 mm minimum size, except superheater outlet vent shall be 50 mm minimum size. Test gauge connection 25 mm sizes.

19.7 Protection SS shields to be provided in the leading rows of economiser and superheater coil bends and hanger tubes where the high velocity flue gas can possibly erode the tubes.

19.8 The total superheater surface area shall be sized, distributed and located to maintain the superheated steam temperature at superheater outlet over the entire steam temperature control load range as specified. The superheater sections shall be of drainable type and shall permit dry running during start-up and transient conditions. Further, care shall be taken to reduce header diameter and hence thickness, reducing possibility of fatigue damage by increasing the number of header outlet steam pipes.

19.9 A spray attemperator shall be provided between primary and secondary super heater with necessary control valves controls. A thermal sleeve fitted with removable liners shall be provided in the attemperator pipe, to ensure that spray water cannot impinge on the pipe wall and cause cracking. The spray water shall be taken from the feed system, upstream of the feed control valves. A spray control valve, operated by the automatic steam temperature controls shall be included.

19.10 The superheater shall be designed with the saturated and superheated steam headers outside of the boiler setting for maximum accessibility and tubes so arranged as to permit easy replacement.
19.11 Steam temperature at superheater outlet shall be maintained within limits, as specified by attemperation as mentioned in Process design philosophy by means of remote manual and automatic control devices. The Superheater system shall preferably combine the radiant and convective surfaces, to achieve the rated steam temperature as specified in the process design basis.

Manufacturer shall provide sufficient nozzles for each of the following:

1. Superheated steam (outlet header)
2. On main Safety valves (outlet header)
3. Superheater drains & vents (inlet & outlet headers)
4. Start-up Valve
5. Sampling (outlet header)
6. Soot Blower Steam (if required)
7. Superheater attemperator vent
8. All others required for complete installation, including tape for thermo walls and steam gauges

19.12 Suitable number of permanent thermocouples for use in observing tube metal temperature during starting up shall be installed. These thermocouples shall be terminating in a suitable junction block.

Contractor shall elaborate design features for preventing thermal stresses during start arrangement of support and spacers to take care of differential expansion of various components. Superheater tubes shall be seamless and tubes and supports shall be of suitable material for long service.

19.13 Molybdenum wherever used in alloy for super heater material, should be suitably stabilized with requisite amount of vanadium and chromium. Alloys containing molybdenum will not be accepted.

19.14 Liberal margins shall be provided over calculated metal temperatures and well over the IBR stipulations, to ensure trouble free and reliable SH surfaces, and assured cooling under all operating conditions.

19.15 The super heater system design shall provide provision for future addition of heating elements to the extent of atleast two loops in primary super heater. The location of headers and primary SH tubing shall be so arranged that this additional surface addition shall be made possible with least disturbance to the existing pressure part system.

20.0 STEAM DRUM

20.1 Steam drum shall have adequate storage capacity (minimum storage of 1 minutes between recommended normal level and permitted low low level) so that in the event of tripping of running feed pump, the standby feed pump starting automatically shall be able to prevent tripping of the boiler from low low drum level while boiler was operating at MCR and with normal drum level.

20.2 Drums and headers shall be located away from the hot exhaust gas path.
The longitudinal and circumferential welds shall be properly heat treated and 100% radiographed during manufacture. The interior of the drums shall be cleaned to remove mill scale, rust, corrosion products, dirt, grease, moisture or other loose foreign materials, after fabrication at works either by shot blasting of nonsilica bearing grit or as per the manufacturer's standard cleaning process meeting the Owner's approval.

20.3 Steam drum shall be equipped with suitable moisture eliminators, screens and other necessary internals to ensure adequate dryness. The drum internals along with the steam-separating device shall direct the flow of steam and water so as to obtain an optimum distribution of drum metal temperature over the entire operating range. The arrangement and fabrication of the drum internals shall permit easy removal and replacement of parts through drum manholes. The drum dished ends shall be provided with properly sized manholes and hinged manhole covers of forged steel secured by forged steel yokes and bolts. The feed water pipes from the economizer entering the drum shall be spaced suitably so that there is no uneven distribution of flow over the entire length of the drum.

20.4 The steam drums shall be designed and fabricated in accordance with IBR latest edition.

20.5 The drum internals shall be of steel & bolted construction and shall be such as to allow parts to be removed single handed. The steam drum shall be provided with suitable type separators, screens and other necessary internals, to guarantee adequate dryness of steam.

20.6 The steam drums shall contain the following minimum connections:
   a. Safety Valves with silencers
   b. Pressure Gauge
   c. Steam Outlet
   d. Chemical Feed
   e. Riser Connections
   f. Down comer Connections
   g. Feed water Inlet
   h. Drum Vent
   i. Drum drains
   j. Continuous Blow-down
   k. Drum level indicators
   l. Test Gauge
   m. Nitrogen blanketing
   n. Manhole doors on either side of drum.

20.7 Drums shall be fusion welded, and constructed in accordance with the applicable codes stress relieved, and 100% radio graphed. All nozzles shall be welded to the drums. The nozzles shall be long enough to ensure that the base welds are not affected by any subsequent welding at site and that valve, mountings and fittings can be cut off and re-welded without damaging the lagging and the drum body.

20.8 The drum shall be of circular cross section and of sufficient diameter to ensure easy access for repairs and inspection.

20.9 Dryness fraction of the steam at the outlet of moisture eliminator shall not be less than 0.999

21.0 BLOWDOWN VESSELS
21.1 Continuous blowdown tank (CBDT) shall be designed for continuous blowdown of boiler operating at M.C.R. The continuous/intermittent blow down shall be taken as 3% minimum. The continuous blowdown tank shall be designed for a pressure mentioned in Process Design Philosophy and shall meet IBR requirement.

21.2 The continuous blow down from the steam drum shall be brought to the flash tank, operating at low pressure. The flash vapour shall be connected to deareator.

21.3 The vessel inside shall be equipped with multi nozzle distributor for efficient spray and flashing of the blow down water.

21.4 The sizing of vessel shall take into consideration the continuous operation of boiler at MCR conditions. It shall be a vertical cylindrical vessel. The Flash Vessel shall be kept at a suitable elevation for proper draining of same under maximum blow down to Atmospheric Blow Down Vessel under all operating modes and even during start-up when there is possibility of pressurisation. However, the pressurization shall be such that maximum drainage from Flash Vessel to Atmospheric Blow Down Vessel is not affected.

21.5 The vessel shall be complete with all appurtenances, like:

- Level gauge
- Level transmitter and controller
- Pressure gauge
- Pressure transmitter
- Drain control valves
- Manhole with cover
- Pressure safety valve

21.6 The internals of the Vessel shall be designed to prevent entrainment of water particles in the vapour as it is vented out and the walls shall have extra thickness at and around the point of entry of blow down.

21.7 The continuous and intermittent blow down lines from each steam drum shall be led independently to the Flash Vessel.

22.0 SOOT BLOWER CONTROLS & PIPING

22.1 Soot Blower (If required) shall be as per proven Technology.

22.2 Suitable arrangement for pressure reduction and temperature adjustment (if needed) shall be furnished to obtain steam for soot blowing. All soot blowers located in high temperature zone shall be retractable type located on both sidewalls of boiler and covering half the effective boiler width when fully extended.

22.3 This shall permit operation of any group of soot blowers repeatedly in sequence as necessary and also permit omission of any soot blower(s) in a cycle.

22.4 The contractor shall furnish soot blowers for superheater, economiser and the air heater, complete with all piping and accessories, including valves, controls, panels, motor control centre, complete with starter and wiring.
22.5 All soot blower elements located in a temperature zone of 815 Deg. C (1500 Deg. F) or higher, shall be of the retractable type. The retractable blowers shall be located on one/two side walls of the boiler and shall cover effective width of the boiler.

23.0 BURNERS

Burners selection shall be compatible to type of Boiler technology selected i.e. PF/CFBC.

23.1 Burners consisting of gun assembly, air nozzle assembly, combustion air damper assembly, refractory lined muffle block assembly, fittings, nuts & bolts. Nozzle tip material specification shall be minimum SS310. Material specification of other metallic parts shall be minimum SS304.

23.2 Each burner shall be easily removable for ease of maintenance.

23.3 Burner flame shall not impinge on furnace water wall.

23.4 Inspection & Testing of Burners:
   a) Burner performance tests, witnessed by Owner and/or Owner’s representative.
   b) Pressure testing.
   c) 100% radiography of butt joints.
   d) Dye penetrant test of all welds.
   e) Complete dimensional check.

23.5 Low NOx Burners shall be provided.

24.0 STACK

24.1 Dedicated stack for each boiler is envisaged for the Steam Generation Plant Stack design shall be as per Process & Civil Design Philosophy (ITB section 5.1 & 5.5).

24.2 The stack shall be of self supporting type and shall be of RCC material. The minimum height of stack above grade level and the exit gas velocity must confirm to the requirements of both National and Local authorities.

24.3 The stack design shall be such as to prevent flue gas inversion.

24.4 The stack shall be equipped with approved lightning protection system, aviation warning light (with re lamping provision) along with suitable access platforms and ladders for the measurement points and others. The ladders in the stack shall be provided as staggered one.

24.5 The Stack entrance and exit velocities of gases shall be as per standard design practice.

24.6 Stack pollution control monitoring system and sampling arrangements shall be inline with CPCB and state pollution board norms/guidelines.

24.7 Drain shall be provided so that rain water doesn’t collect at the bottom of boiler exhaust stack.

25.0 Lime Handing System:
25.1 Lime handling system (if required) for sulphur catch up should be provided. Sulphur capture is influenced by various factors i.e. fuel properties, sulphur content, calcium to sulphur molar ratio, lime stone reactivity, furnace temperature, gas and solids residence lime and lime stone particle size. For detail design, refer Design Philosophy-Material handling.

26.0 Steam Generator Enclosure:

26.1 The entire steam generator shall be constructed to form a complete gas tight construction without any perceptible leakage of exhaust gas from within the setting under any condition of operation.

26.2 The design and construction of enclosure shall prevent distortion of steel work due to thermal expansion and deterioration of insulation. The primary objective of enclosure design shall be to achieve reliability and long life.

26.3 Observation ports, doors and all other openings shall be provided with sealing air to prevent hot gases from blowing out when these items are opened or operated. All inspection doors and access manholes shall be of the quick opening type and provided with safety features to prevent opening of the doors without seal air pressure when the boiler is in operation.

26.4 A complete system of walkways, galleries, platforms and stairways shall be provided on all sides of the unit as required for proper operation and maintenance and easy access to inspection doors and manholes.

Provision shall be made in the steam generator casing and access platforms for the rapid and convenient installation of the inspection scaffolding furnished for maintenance and inspection.

26.5 For all temperature measurements within the steam generator casing, the bidder shall furnish temperature elements and wiring to junction boxes outside the casing in respect of local as well as remote measurement. All necessary access, observation, and cleaning doors with frames shall be provided. The doors shall be insulated and be perfectly gas tight under all working conditions. The design and construction of the doors shall be rugged and shall ensure freedom from distortion.

27.0 ELECTRO STATIC PRECIPITATOR (ESP):

27.1 Introduction:

The ESP design and sizing shall specifically take into account, the probable characteristics of flue gas and the range of particle size and distribution of flyash entering ESP, with the type of PF/Fluid Bed Combustion process proposed, and duly considering the equipment and systems installed as part of boiler ahead of the ESP units. ESP shall be designed considering N-1 philosophy, where N is the number of installed streams of ESP.

27.2 Dust Collecting System and its Sizing:

It has been proposed to install Independent Electrostatic Precipitator system per boiler of single stream gas pass design, with adequate no. of independent electrical fields, optimally located in the layout to match the boiler.

The contractor shall furnish along with his offer the detailed calculations & data for ESP efficiency, ESP power consumptions and T-R set rating etc.
All the design procedures, systems and components proposed shall have already been adequately developed and have demonstrated good reliability under similar or more arduous conditions elsewhere.

The bidder shall submit with the offer, comprehensive information on the how the specific collection area, effective migration velocity or total migration velocity of the proposed design has been arrived at. Contractor shall submit along with offer, a detail write-up on the proposed design features with recent design modifications, if any, and the specific advantages over the previous design.

The design of ESP shall permit the installation of ash handing equipment at the inlet & outlet of ESP. Further, Ash extraction system will be installed at the bottom of ESP hoppers. 

Minimum 2 m wide platform shall be provided between two casings of the ESP to facilitate maintenance work and minimum 1.5 m wide platform shall be provided all around the ESP passes at intermediate and T-R set elevations. Minimum 1.0 m wide platform hall be provided all around the Hopper at hopper level.

The protection for rapping motor from exposure to rain shall be provided.

ESP Requirements:

The flyash dust collecting system shall be designed conservatively and liberally sized, to handle ash dust. The Electrostatic Precipitator design and technology offered shall be of well proven type to handle the dust concentration content in flue gas. Accordingly, the ESP design offered should have demonstrated excellent performance and operational reliability over the years, for similar or larger applications.

Ducting System at ESP Inlet & Outlet:

The complete inlet and outlet funnel duct work system of ESP shall form part of ESP proper, which shall be provided with required gas distribution devices to ensure uniform gas flow across ESP cross section, under all operating conditions.

Also the ESP supplier shall recommend, for providing any guide vanes in the inlet ducting section from the boiler for improving the gas flow and for achieving improved ESP performance.

ESP, ducting and structures design shall be as per IS-875 latest standards for wind loads.

The entire ESP system, and all auxiliary equipment including all Electric, HVTR sets etc. shall be designed for "Outdoor" duty conditions.

Very special care shall be, accordingly taken to protect all critical equipment, with weather proof enclosure etc. as required.

Parameters for ESP Design and Guarantees:
The main parameters for ESP design and sizing, corresponding to "BMCR parameters" shall be based on the predicted flue gas parameters as per the fuel analysis furnished, in this specification.

27.3 Specific Requirements:

The "ESP design" shall consider maximum sulphur content as per fuel composition.

The outlet dust concentration shall not exceed 30mg/Nm³ in first field OUT condition of ESP.

The maximum flue gas velocity through the ESP shall not exceed 1.0m/sec, at rated design parameters, to ensure efficient collection without re-entrainment losses.

The maximum draft loss across the complete ESP section, shall not exceed 25 mm WC, under its rated conditions.

Minimum aspect ratio of the ESP (electrode zone) shall be 2, so as to minimise re-entrainment and carryover of the collected dust, and ensure better ESP performance.

The treatment time of flue gases shall be sufficiently long enough for proper unit performance with the specified duty conditions. Further, Treatment time of flue gases shall be minimum 20 seconds.

The ESP shall be selected and sized with optimum dimensions (width, height, length) etc. to ensure reliable performance and high collection efficiency, even under conditions of one of the fields out of service.

The casing shall be provided with required number of gas tight access doors, for maintenance. The ESP casing near inlet and outlet funnel sections shall also be equipped with access doors.

The minimum required steel plate thickness for casing, ash hoppers etc. shall be as below:

For ESP side walls and roof - 5mm
Inlet and outlet funnel sections - 5mm
Complete Ash hopper - 5mm

ESP structure shall be provided with Corten (Weathering) Steel

Precipitator Casing and Insulator compartments:

Precipitator and equipment shall be functionally and structurally designed to with stand all of the following without exceeding the maximum allowable stresses of the AISC code.

Continuous operation with a flue gas temperature upto 55°C above the specified inlet temperature, and operation for one hour with a flue gas temperature of 400°C in the case of a cold precipitator.

The precipitator shall be designed and suitably reinforced to eliminate detrimental vibration.
Suitable inlet and outlet connections shall be supplied for welding or bolting to connecting ducts.

The precipitator shall be equipped with necessary hinged inspection and access doors properly key interlocked with “Danger-High Voltage” signs for safe operation and maintenance. All inspection and access doors shall be capable of gas-tight sealing even after repeated openings and closings.

Internal baffling shall be provided to prevent gas and dust leakage above, below and around the active precipitator zones (if required).

Walkways between series fields shall be provided to facilitate inspection and maintenance at the bottom of the precipitator collecting plates. Access to the top of the precipitator in the region of discharge electrode connections shall be provided.

All horizontal surfaces shall be sloped to ensure drainage of rainwater. Wherever required, external gutter or drain pipes shall be provided to drain out accumulated water.

**Ash Hoppers:**

All ash hoppers shall be of pyramidal type of identical size and capacity to avoid arching or clogging. Storage Capacity shall be minimum eight hours corresponding to the minimum 70% ash collection rate in the first field.

Specific weight of ash shall be assumed 650 kg/m³ for calculating the storage capacity and 1350 kg/m³ (Minimum) for structural design.

Each hopper shall be complete with an access door, ash outlet flange terminated at 2.75 M above +0.00EL Hopper valley angle shall not be less than 55 Deg. To the horizontal and ensure free flow of ash from hopper outlet.

Each hopper shall be provided with a hopper heating system (thermostatically controller type) in order to facilitate smooth ash flow.

All hoppers shall be equipped with suitable gas tight key-interlocked hinged access doors with “DANGER-HIGH VOLTAGE” sign.

Platform at the bottom of each hoppers shall be provided.

Ash storage capacity shall be at least 10% higher than the ash storage capacity theoretically required for each dust hopper.

The number and arrangement of dust hopper shall be such that there is at least one dust hopper per T-R set.

Hopper shall be of welded steel pate construction with 5 mm minimum plate thickness. The lower one third or 1.5 m whichever is higher shall be lined with 16 Gauge or heavier, type 304 SS.

The dust hopper shall be electrically heated up to a minimum of lower one third (1/3) of dust hopper height but not less than 1.5 m by thermostatically controlled panel type heating element to prevent ash bridge formation in addition to panel heater, wrap around
heater/pad heater suitable for curved surface i.e. curved foil based heating element of required KW size (about 0.5 KW min.) to maintaining minimum ash temperature of 104 degree C above knife edge gate valve shall be provided on conical portion of hopper or adaptor as applicable. All heaters on each level shall have same wattage capable of maintaining internal hopper temperature in excess of 140 degree C. Heating element shall be of sturdy construction and made with inconel 600(punched type) or flat type nichrome foil suitable for ESP application. These heater shall have design life of 25 years.

Each hopper shall be provided with Two(2) nos. of hundred (100) mm diameter poke hole in mutually perpendicular direction with threaded caps. The cap shall have flat iron bars suitable for striking with a hammer, to assist in breaking free in any seized threads. The hopper adaptor piece, spool piece and bend up to knife edge gate valve shall also be provided with suitably designed and located rapping anvils for loosening the fly ash by striking with sledge hammer.

Each dust hopper shall be provided with high level & low level dust monitor on proven radio frequency measurement system. The level monitoring control system shall incorporate all the necessary accessories including two no. Level switches per hopper (1 for high & other for low level) each with 2 NO+ 2 NC contacts, local & remote signally lamps and high & low level alarms.

The high level ash switch will provide contact closure and activate the alarm when the ash level reaches a level high enough to cause deterioration of ESP performance and possibility of damage to ESP structure if not corrected. After a preset time elapse with the ash under high alarm activated, the logic shall have provision to de-energize the T-R set of the particular field of the effected ash hopper. The level control device shall be unaffected to by ash built up, due to moisture or charged ash on either the hopper valve or on the probe itself.

Each hopper shall be provided with a quick opening access door of not less than dia. 600 mm. Suitable access ladder shall be provided from the walkway beneath the hoppers to facilitate approach to the access doors.

27.4 The "ESP design" shall consider maximum sulphur content as per fuel composition. The percentage of carbon in the fly ash entering ESP shall be considered upto 3% of fly ash by weight for design.

27.5 Collecting Electrodes

The collecting electrodes shall be fabricated from Cold Rolled Cold Annealed (CRCA) steel plates of minimum 1.2mm thickness suitably profiled for good corona Characteristics, rapping characteristics, ash collection and disposal with minimum e- entrainment.

The plates shall be designed to withstand the high energy impacts involved in rapping without permanent distortion or overstressing. The plates shall also be capable of withstanding the stresses involved in field handling and shipping without damage.

The collecting electrodes and their supporting assemblies should be capable of continuous service at 55°C above the normal operating temperature and at 200°C for one hour in the case of a cold precipitator.

The collecting electrode system shall be electrically grounded to the precipitator shell and structure.
The collecting electrode assembly shall be designed and manufactured to the erected plumb and to remain so aligned for the life of the equipment.

The profile of the collecting plate (single piece construction) shall be such as to minimise the reentrainment of collected dusts at the time of rapping.

27.6 Discharge Electrodes

The discharge electrode design, geometry, size arrangement and material shall be of well-proven type, considering specified duty conditions and for achieving uniform corona power, reliable operation, performance and long life.

Discharge electrodes shall be constructed from durable, corrosion and erosion resistant material. In case, spiral type discharge electrodes are being offered, the material for the same shall be UHB904L or equivalent.

The discharge electrodes are to be mounted in rigid frames. The frames are to have sufficient intermediate bracing.

Mechanical terminations and connections of discharge electrodes to support frames, shall provide sufficiently positive electrical contact to prevent pit arcing and premature failure, and shall eliminate undue mechanical stress leading to metal fatigue and breakage, particularly those stresses associated with high-tension rapping operations, or mass flow of gas.

Electrodes designed to operate in tension shall have this tension verified prior to commissioning the precipitator. Adequate precautions shall be taken to ensure good electrode stability, straightness and current-density distribution under normal precipitator operating and design conditions as covered in these specifications.

Discharge electrode system and high-tension rapping arrangement shall be designed and constructed to avoid nodal regions where some discharge electrodes do not receive adequate rapping energy to remove dust deposits.

High tension electrode frame and support system shall be such that no swinging, rocking, or oscillation occurs during normal operation, either in the frame or in the discharge electrodes themselves.

High-voltage insulators electrically isolating the discharge electrode system from the shell and ground shall be of adequate length, strength and electrical properties for proper operation of the precipitator under all design and specified conditions of service.

A suitable high-voltage bushing or insulator heating system shall be provided to prevent moisture condensation during start-up sand during operation where dew-point problems may occur. A system to supply clean, dry air shall be provided (where necessary) to keep high-voltage support insulators free of excessive dust deposits.

Measurements determining electrode alignment shall be made at the top and at the bottom of the plates and at such other places between top and bottom as may be required to ascertain the true nature of the quality of electrode design, construction and assembly to achieve proper alignment.
27.7 Rapping System

The rapping arrangement and system shall be independently arranged for the collecting electrode system and emitting electrode system. Electromagnetic/MIGI/Tumbling hammer type of rapping system shall be employed to provide required acceleration in all sections of the collecting electrode for the specified duty conditions.

Provision shall be made in the design for adjusting the frequency of the rapping system. Provision for rapping adjustment shall be made and such adjustment shall be feasible, while ESP is operating.

Rapper Controller (RPC)

a) Each stream of ESP shall be provided with a separate, microprocessor based Rapper Controller (RPC). However, any other proven standard design of rapper controller integral to TR set controller is also acceptable.

b) It shall have proven noise immunity and shall be suitable for ESP application.

c) It shall control the sequence and frequency of operation of the rapping mechanisms of collecting and discharge electrodes of the different fields of the precipitator.

d) The unit shall control and survey the operation of rappers in the ESP. It shall start and stop the rappers as programmed and shall give an alarm if a rapper fails.

e) It shall be possible to start or stop manually each rapper, without interfering with the other rappers from the controller. The operation status of each rapper shall be indicated with LEDs on the rapper controller panel.

f) It shall be possible to change the three timings (viz. Start time, repetition time and run time), intensity (if applicable) and frequency of rapping independently for each rapper, without need for opening the panel or any alternation in programme.

g) The range of rapping frequency available shall be up to 24 hours. Additionally, the rapper controller shall have adequate Pre-programme sequences of rapping stored in its memory so that the operator can select any of them according to his judgement or the controller itself can choose them based on feedback from boiler load.

h) In case one separate rapper controller is provided for each stream, one standby working rapper controller shall be provided so that in case of failure of any one of the working rapper controllers, the standby controller shall immediately and automatically take over the control functions of this rapping without affecting the operation of ESP.

i) The system shall have the following minimum features:

   (i) Display of all adjustable parameters, rapping modes, time settings and intensity of rapper/group and rapper status, rapper alarm and controller alarms.

   (ii) Key board for operator interface.

   (iii) Local/ Remote selection: In local mode all commands and adjustments shall be from RPC. In remote mode all commands and adjustments shall be from EPMS.

   (iv) Communication port with protocol for communicating with EPMS.

   (v) Remote on/ off capability from EPMS.

   (vi) The controller address (field programmable), logic programmes and other adjustable parameters shall be stored in non-volatile memory and shall not be affected by power loss.
(vii) All internal part of rapping mechanism shall be accessible for inspection and they shall be placed on wide access passages and shall be easily accessible for operational and maintenance purposes. Major part of rapping mechanism shall be located external to the precipitator. Necessary lubrication system shall be provided for the rapping mechanism.

27.8 Transformer Rectifier

The Transformer Rectifier (TR) sets shall be optimally sized and shall have the required electrical ability under sparking conditions. TR sets shall be three phase. Technical requirements of Electrostatic Precipitator (ESP) Electrical equipments like motors, cables, ACP/MCC etc., which are not covered in the following clauses, shall be as per specifications of PDIL attached with this specification.

Transformer Rectifier (TR) Sets.

a) Transformers shall conform to IS: 2026. The transformer oil shall meet the fire safety requirements specified in paragraph 450-23 of National Electric Code. All other equipment/ accessories shall conform to relevant Indian Standards. Equipment conforming to equivalent International Standard like IEC shall also be acceptable.

b) Equipment Description

i. Type: Silicone oil filled, free standing transformer rectifier assemblies in steel housing with HV disconnect and ground switch for each section of the ESP field.

ii. Tank: Welded type construction. Tank cover shall be sloped to prevent retention of water and shall be provided with bi-directional skids, lifting lugs and four jacking pads.

iii. The TR enclosure access doors shall be key interlocked with the main power supplies and adequate grounding provisions for personnel safety shall be provided.

iv. The rectifier shall be of Class IP-55 and panel shall be of Class IP-4X.

v. Core: High grade non aging cold rolled grain oriented sheet steel laminations.

vi. Oil: The transformer oil shall be non toxic and shall have high flash point (above 300 Deg Celsius) sealed type construction without breather.

vii. Winding: Electrolytic Grade Copper.

viii. LV Connection: Cable.

ix. Cable Box: Degree of Protection IP-55.

x. Bushings: Made of Porcelain.

xi. Marshalling Box: Degree of Protection IP-55, provided with thermostatically controlled space heaters.

xii. TR Set Controller Panel: Provided with isolating switch, power contactor, thermal overload relay, fuses for protection of Silicon Controlled Rectifiers, etc.

c) Fittings

i. Temperature Indicator: Dial Type oil temperature indicators with alarm and trip contacts.

ii. Drip Trays: To contain total volume of cooling fluid.
iii. Drip Trays: To be connected to a separator chamber through drain pipes. The separator chamber located at ground level to be sized to contain oil from drainage of any two TR sets.

iv. Pressure Relief device: Spring Loaded Type.

v. Oil Level Indicator: Magnetic with low level alarm contact.

vi. Oil Level Gauge: Prismatic/ toughened glass.

vii. Buchholz Relay: Double float type with alarm and trip contacts.

viii. Winding temperature Indicator.

d) Operating Conditions

Operation of precipitator shall not be affected when one rectifier unit is taken out of service.

i. Flux Density: Flux density not to exceed 1.9 Wb/m²

ii. V/f: Designed for 1.1 continuous.

iii. Noise level: Not to exceed the values specified in NEMA-TR-1.

iv. Protection: Suitability for working under transient sparking conditions and occasional short circuit load. Protection against surge, excess temperature rise and under voltage to be provided.


Oil : 50 Degree Celsius

All required mounting brackets, grounding and mounting materials shall be furnished for attaching the TR assemblies to the precipitator. The supporting structure for the TR assemblies shall be designed to contain the fluid that could leak from damaged set. Output terminal grounding switches that are interlocked with the overall system shall be included.

27.10 ESP Insulators

a) High voltage insulator shall be located outside the gas stream, suitably housed in the insulator compartments to facilitate maintenance when the precipitators are on load.

b) High-voltage insulators electrically isolating the discharge electrode system from the shell and ground shall be of adequate length, strength

c) Each insulator compartment shall be provided with insulator heaters or hot air ventilation system to avoid moisture condensation on insulators. In case of hot air system, it shall include fans, air filters, heaters etc.

d) The insulator compartment shall be provided with thermal insulation. The compartment shall be designed such as to prevent ingress of flue gas into compartments.

e) Insulators for supporting emitting frame and roof bushing shall be of porcelain suitable for long life, in ESP internal environment (highly polluted with flue gas temperature of 200 Degree Celsius and going up to 300 Degree Celsius for 5 minutes).

f) A suitable high-voltage bushing or insulator heating system shall be provided to prevent moisture condensation during start-up sand during operation where dew-point problems may occur. A system to supply clean, dry air shall be provided (where necessary) to keep high-voltage support insulators free of excessive dust deposits.
27.11 Earthing and shielding

a) A complete earthing system with double path to the ground for all equipment and ESP structure shall be furnished. Each casing shall be provided with two earthing pads located on diagonally opposite corners of each casing. The pad surfaces shall be tinned drilled and shall be connected to earthing mat by 50x6 galvanised steel flats.

b) Manual safety earthing devices shall be furnished so that individual equipment can be grounded during maintenance. All access doors, gas distribution baffles or perforated plates located in the inlet or outlet nozzles of the precipitators shall have ground straps connected to the precipitators casing if they are not welded permanently to the casing.

27.12 Safety Interlocks

a) A full proof manual key sequence type interlock system for the safety of operating personnel from contacting energised high voltage equipment shall be provided. Key interlocks shall be provided such that for a particular ESP casing any TR set cannot be energised until all insulator housing compartments, disconnect switch boxes, casing inspection doors are locked and emitting and collecting electrode rapping motors are prevented from energisation. It shall also prevent opening of any inspection door unless all TR sets of that stream are de-energised and all HV disconnect switches are opened to earthed position. Rapping motors operation shall be prevented under this condition unless interlock is specifically defeated for testing.

b) Key interlock system shall be simple, robust, weather proof construction suitable for outdoor mounting.

27.13 ESP Control System

a) The control system shall be designed for automatic and manual local/remote operation.

b) ESPs serving one boiler shall be provided with a complete control system consisting of microprocessor based Electrostatic Precipitator Management System (EPMS), TR set controllers, rapper controllers, communication controllers, hopper heater controls, insulator heaters and pressurization system controls and all other controls required for safe, efficient and reliable operation.

27.14 Electrostatic Precipitator Management System (EPMS):

a) The EPMS shall be connected to the Transformer Rectifier Set Controllers (TRC) and Rapper Controllers (RPC) through duplicate data highway. However, any other standard, proven system of communication through balanced current loop is also acceptable.

b) EPMS shall accept the feedback analogue signals and issue control parameters to the TR Controllers and Rapper Controllers. It shall also control, monitor and display the status of each stream i.e. status of TR Controllers, Rapper Controllers, hopper heaters, hopper levels, insulator heaters/pressurization air blowers etc.

c) The EPMS shall include, but not be limited to, the following features:

(i) A PC based master controller with non-volatile memory and report storage capabilities for a period of 6 months.

(ii) TR Set Controllers and Rapper Controllers.

(iii) High resolution 21” colour CRT.
(iv) Communication ports and protocol for data transfer between EPMS Master Control Unit and the TRC/ RPC/ other controllers.
(v) Keyboard for operator interface.
(vi) Colour inkjet printer for alarms and reports.
(vii) Facility for Auto operation of ESP with Energy Management.
(viii) Necessary Input/ Output points for interfacing with distributed digital controls and Management information system (DDCMIS).
(ix) Self surveillance and self diagnostic features.

d) The EPMS display unit shall display at least the following:
(i) A summary of the status of all the controllers.
(ii) A summary of the readings of all the TR sets.
(iii) A summary about each TRC i.e. settings, limits, voltage and current readings, alarms and the controller status.
(iv) A summary of each RPC i.e. controller status, rapping frequency, alarms and indication of the rapper being operated.
(v) Status reading Energy Management System such as charge ratio of each field etc.
(vi) Necessary alarms as decided during detail engineering stage.
(vii) Status of hopper level, hopper heaters and insulator heater/ blower.
(viii) ESP TR set power supply status and alarm.
(ix) Potential free contact for ESP trouble shooting etc. as required shall be provided.
(x) The PC based master controller i.e. operating and monitoring station together with 21" colour TFT, keyboard and colour inkjet printer shall be located in the unit control and equipment room/ programmer’s room for each unit. Necessary links with the DDCMIS shall be provided so that all the functions of the master controller can be performed from operator’s work station of DDCMIS.

27.15 TR Set Controllers:
A separate free-standing control cabinet shall be supplied for each TR unit. It shall be designed to permit the control equipment to operate properly at ambient temperatures up to 50°C in a dusty indoor environment.

a) Each Transformer rectifier set shall be provided with a separate microprocessor based controller (TRC) for regulation and control of the electric power input to electrostatic precipitator fields.

b) It shall be designed for minimum charge ratio of 1:99.

c) It shall automatically optimise the charge ratio and maintain the spark rate at a suitable level for variations of gas temperature, dust composition, gas flow etc.

d) It shall regulate the rectifier in such a way, that the current through the electrostatic precipitator is corrected as the conditions for sparking are changed. It shall be able to monitor filter functioning and shall give an alarm when values are lower or higher than preset values.

e) It shall automatically regulate the charge ratio of each field/ TR set based on V-I characteristics of the respective electrical fields.
f) It shall have alternative arrangement of optimising the charge ratio based on Opacity Monitor signal also for monitoring dust emission in terms of mg/Nm³. The system shall include all devices, software necessary for computing Dust and shall be designed to operate with flue gas temperature between 100 to 200 degree C continuously.

g) The controller shall have proven noise immunity and shall be suitable for ESP application.

h) It shall be capable of maintaining the optimum voltage and current in ESP under all regimes of boiler operation.

i) Full-rated output load current shall be available over full output voltage control range.

j) A current-limit control adjustment shall be available over full rated current range. There shall be no interaction between this control circuit and any other automatic control circuit (e.g. average spark rate, or threshold sparking level).

k) Precipitator voltage control shall be fully automatic from 0-100% rated output. For testing and maintenance, an Automatic-Manual switch shall be provided with provisions for manually regulating voltage at the control cabinet.

l) Automatic voltage control system must be capable of reliable, stable operation, including precipitator sparking, over the full output control range. System must be capable of adjustment for continuous operation, automatically maintained at threshold sparking level up to low average sparking rates (e.g. 5-10 sparks per minute maximum). The controller shall be suitable for back corona, spark rate, semi-pulse control.

m) The system shall have the following minimum features:

   (i) Display unit for:
       - All the operating values like field DC voltages and currents
       - Spark rate
       - Semi pulse current limit
       - Voltage low limit
       - Charge Ratio
       - All other adjustable parameters and limits

   (ii) Keys for operator interface and potentiometers local control and adjustments.

   (iii) Serial communication with protocol for communicating to EPMS.

   (iv) Local / Remote Selection.

   (v) Spark Counter.

   (vi) Alarms as mentioned below:
       - TR set oil level low.
       - TR set temperature high.
       - AC current high.
       - Low DC voltage.
       - High DC voltage.
       - Back Corona.
       - Management command failure.
       - TR set Buccholz/ PRV trip.
       - TR set Buccholz alarm.

27.16 High Voltage Wiring
All equipment needed to connect the transformer-rectifiers to the discharge electrodes shall be provided. This shall include weather proof metal-enclosed bus ducts.

The bus ducts shall be furnished with all necessary insulators, fittings and gaskets and shall be formed to exact length and flanged for bolting to the precipitator.

A system for heating and ventilating the high voltage insulators shall be provided. Automatic control devices for the heaters shall also be provided. A stand-by fan shall be provided for each system.

27.17 Voltage Controls and Cabinets

A separate free- standing control cabinet shall be supplied for each TR unit. It shall be designed to permit the control equipment to operate properly at ambient temperatures up to 50°C in a dusty indoor environment.

All adjustments needed for normal operation of the precipitators shall be made at the control cabinets and shall not required e-energizing the bus sections.

Solid state control hardware shall be provided to determine and monitor the electrical performance and to automatically regulate the high voltage current to the TR sets.

Precipitator voltage control shall be fully automatic from 0-100% rated output. For testing and maintenance, an Automatic-Manual switch shall be provided with provisions for manually regulating voltage at the control cabinet.

Full-rated output load current shall be available over full output voltage control range.

A current-limit control adjustment shall be available over full rated current range. There shall be no interaction between this control circuit and any other automatic control circuit (e.g. average spark rate, or threshold sparkling level).

Automatic voltage control system must be capable of reliable, stable operation, including precipitator sparking, over the full output control range. System must be capable of adjustment for continuous operation, automatically maintained at threshold sparking level up to low average sparking rates (e.g.5-10 sparks per minute maximum). The controller shall be suitable for back corona, spark rate, semi-pulse control.

Suitable breakers, switches, indicating lights, system overload, under-voltage, high voltage ground return, key interlocks, alarm circuits control and/or protection systems, etc. shall be consistent with good industrial practice and in conformity with all applicable codes.

27.18 General Requirements

To ensure uniform gas flow and distribution throughout the ESP cross section, gas distribution screen system shall be provided at inlet and outlet section of the ESP.

The roof inspection floor of ESP shall be provided complete with patterned type (raised / teared drop) aluminium sheet cladding.

The minimum clear width of Platform and stairs shall be 900 mm. The stairways shall be arranged at one side of the ESP (with maximum slope of 37Deg. to horizontal) from ground...
level to the roof with all required handrails, toe plates etc. Minimum width of tread of stairs shall be 250mm and the rise shall not exceed 200 mm.

The ESP housing shall be of gas and pressure tight envelope. Necessary sealing arrangements to prevent moisture ingress into the casing shall be provided. The housing shall be provided with structural steel supports and shall be stiffened to withstand the system draft satisfactorily.

The ESP TR set lifting/handling arrangement shall consist of a monorail system, with an electrically operated hoisting system for operation from the ground level to ESP roof level. Special tools and tackles for adjustment and maintenance shall be provided.

The ESP design shall be envisaged as a single stream gas pass, with minimum 4No. field arranged in the direction of gas flow. Each field shall have independent HVTR sets with all associated electricals, controls, cables, panels, etc. All TR sets and field arrangements, “mechanically and electrically” shall be of identical design and arrangement.

The Transformer Rectifier (TR) sets shall be optimally sized and shall have the required electrical stability under sparking conditions.

Manufactured materials and sub vendor items shall be despatched to site, on an agreed delivery schedule programme of material supply. It is to be specifically noted that all the supplies shall be made in an acceptable sequence to facilitate smooth erection work.

The ESP sub deliveries and accessories components of similar duty shall be identical and interchangeable. This is also applicable for all mechanical and electrical systems.

For Insulation design conditions a differential temperature of min. 20°C between ambient and casing temperature and wind velocity of 0.25m/s shall be considered.

28.0 BRICKWORK, INSULATION AND CASING

28.1 The Contractor shall design and furnish all brickwork, insulating and other materials required for the complete setting including necessary stiffeners, supports etc.

28.2 All exposed boiler, economiser and flue gas duct surfaces shall be insulated with block insulation so that the surface temperature does not exceed 60°C.

28.3 The complete setting shall be air tight as will be evidenced by pressure decay test at site.

28.4 Suitable taps shall be provided for instruments.

28.5 Steam, feed water piping, various drain and blow down piping etc. shall effectively be insulated.

28.6 All insulated surfaces shall be covered with aluminium sheet as per details specified elsewhere.

28.7 Facility shall be provided for Nitrogen gas preservation with necessary valves, piping etc.

29.0 ELECTRICAL EQUIPMENT:

29.1 General specification for electrical equipment shall be as indicated in Electrical Design Philosophy (ITB Section 5.4).
30.0 Acid Cleaning:

30.1 Provision shall be made to facilitate acid cleaning of the pressure parts. Vents shall be provided for feeding acid and flushing after the wash. Diagrams of connections shall be furnished. All valves shall be furnished by Contractor. Steam requirement for acid and alkali cleaning for new boilers will be supplied by the Purchaser.

31.0 INSPECTION AND TESTING

31.1 Equipment shall be inspected by TPIA/IBR (as applicable). The Inspection and testing shall be in accordance with the relevant codes, standards, specifications. All equipment & bought out items shall be inspected during various stages of manufacturing starting from identification of materials to final completion as per agreed QAP which shall be prepared by Contractor and shall duly approved by Owner/ it’s authorised representative. In case of site fabricated/assembled equipment same inspection agency shall be responsible for inspection and testing at site. The guidelines for minimum inspection requirements are listed & also defined under Inspection & Testing clause of the design philosophy.

31.2 All testing accessories, measuring instruments including NDT testing equipment, etc. shall be arranged by Contractor.

31.3 When spot radiography is specified all T-joints & min. 10% of total weld length excluding T-joints shall be radiographed.

31.4 Radiography of welds in C- 1/2 Mo & Cr- Mo - Steel preferably is carried out after heat treatment.

31.5 Hardness test on welds of Cr-Mo, materials after final heat treatment shall comply to ASME requirements.

31.6 All completed equipment shall be tested hydraulically as per the requirements of specification/codes in presence of the inspecting authority. Pneumatic test of completed equipment shall be carried out only when specially mentioned in the specification sheets. Chloride content in water used for testing shall not exceed 30 ppm for SS equipment and 40 ppm for CS and low alloy steel equipment. Duration of test shall be 1 hour minimum. After hydro testing stainless steel vessels shall be dried thoroughly, immediately after draining to prevent the possibility of evaporation & concentration of chlorides.

31.7 When specified, equipment shall be dispatched from manufacturer’s shop filled with nitrogen at positive pressure, fitted with a pressure gauge and valve.

31.8 Equipment under preview of statutory bodies shall be inspected during various stages of fabrication by their authorised inspecting agency. It is the responsibility of the Contractor to get the design calculations and fabrication drgs. approved by concerned statutory bodies before commencing fabrication.

31.9 Unless otherwise stated gasket during testing shall be same as specified for operating conditions. After testing, gaskets used during testing shall be replaced by new gaskets.

31.10 The temperature of test water shall comply with the construction code, but not less than 70°C.
31.11 All SS plates shall be hot rolled & solution annealed and pickled as per applicable code requirement.

31.12 All forgings including nozzle flanges shall be examined for surface defects by MP/PT testing after machining as per code.

31.13 For equipment designed as per Power Boiler code ASME SECTION I, materials shall strictly comply with the requirements of the code. All material must be procured from well known recommended steel makers. All relevant and applicable documents & Drawings shall be approved by IBR.

32.0 FIRE PROOFING
32.1 Fire proofing, if required shall be considered as per OEM's recommendations.

33.0 PAINTING, MARKING & SHIPPING

33.1 Painting:

33.1.1 Painting shall be done as per TS-2001 attached in Construction/Erection, Pre-Commissioning, commissioning & Start-up ITB.

33.1.2 Structural steel which is to be fireproofed, if any, should not be provided with any shop coat.

33.2 Marking

33.2.1 Each supplied item shall be properly identified by Item No., Tag No., or Piece No.

33.2.2 Each bulk material not to be shop-assembled shall be properly marked with material identification.

33.2.3 Marking for erection at the job site shall be provided, and explained in the erection instructions.

33.2.4 Marking on austenitic steels shall be avoided. However, when this is unavoidable, marking material shall be by indelible ink or equivalent.

33.2.5 A nameplate, showing at least Item No., name of furnace, year of furnace erection date, supplier’s name, furnace duty, design pressure, design temperature and hydrostatic test pressure, shall be mounted on each furnace casing on the most accessible point.

33.3 Shipping

(i) All furnace components shall be dry, thoroughly cleaned and free from any dirt or foreign material before shipping.

(ii) All machined surfaces shall be coated with an easily removable rust preventive and suitably protected from damage during shipping.

(iii) End openings of tubing, etc. shall be plugged to prevent entrance of foreign materials.

(iv) When ferritic furnace coils are to be exported, suitable means for rust prevention of coil inside surface, such as enclosure of rust preventive materials or nitrogen into coils, shall be provided.
(v) Bolts, nuts and washers shall be shipped prior to or with first lot of structural steel.

(vi) All bolts, nuts, washers, etc. shall be shipped in kegs or crates and tagged as per size, diameter and length.

(vii) Complete care will be taken while shipping and transportation to avoid damage to fins. Temporary / dummy supports may be provided inside coils, harps to avoid their rattling during shipping/transportation to avoid damage with instruction for their removal before installation.

34.0 SPARES

34.1 Mandatory, Pre-commissioning & Commissioning spares shall be as recommended by LSTK Contractor and 2-Year operation (mandatory) Spares shall be as mentioned at Section-10 in ITB.

35.0 DOCUMENTATION SCHEDULE

35.1 Drawings & Documents shall be submitted as per “Documentation schedule” provided in Section-9 in ITB.
SECTION: VI – 5.3.8

DESIGN PHILOSOPHY – EOT CRANE & HOIST

PLANT: STEAM GENERATION PLANT

PROJECT: INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA).
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1.0 INTENT

1.1 Design, detailed engineering, manufacturing, shop testing & inspection, painting, supply, transportation to site, unloading and storage at site, load testing at site, final painting and Erection & commissioning, requisite statutory approval of Electric Over head Travelling Crane along with runway rails and supply of spare parts for crane as per the technical specifications, terms and conditions mentioned in this Technical Specification.

LSTK Contractor to provide EOT Cranes of adequate capacity in various Steam Generator Unit, Maintenance Bay, Pump Houses, Compressor & turbine House and other location wherever required for ease in operation and maintenance activities. Cranes to be provided in nearest multiple of 5 Metric Tonnes considering maximum weight to be lifted. Relevant Indian/ ISO Standards to be applicable for EOT Crane. The main hook capacity of each crane shall be minimum 25% over and above the heaviest component/ equipment to be handled. 15 T and above EOT cranes shall have 5T auxiliary hoist. All statutory guidelines to be complied by the contractor/ sub-contractor.

2.0 SCOPE OF SUPPLY & ERECTION

2.1 The scope of supply & erection shall be, but not limited to, the following:

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<td>1.1</td>
<td>Design, Engineering, Manufacturing, Testing, Inspection, Supply, Erection &amp; Commissioning of suitable capacity EOT Cranes including its drives and all other relevant electricals</td>
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<td>1.2</td>
<td>Runway Rails for crane along-with necessary fixtures for fixing the rails on structural steel girder, along-with electrical interconnection for the earthing of rails.</td>
<td>Bidder to furnish</td>
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<td>1.3</td>
<td>Mechanical stoppers on both the ends of runway rails for LT motion and for CT motion.</td>
<td>Bidder to furnish</td>
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<td>1.4</td>
<td>Festoon flexible cable type down-shop leads system along with necessary insulators, brackets, lighting etc.</td>
<td>Bidder to furnish</td>
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<tr>
<td>1.5</td>
<td>Access ladder, Platform and safety handrail for EOT cranes</td>
<td>Bidder to furnish</td>
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2.2 CODES AND STANDARDS

The Design, manufacture, performance and testing of the EOT crane as specified herein after shall comply with the requirements of the applicable latest standards and
codes of practice. The latest standards with all amendments shall be followed in particulars.

IS:3177 code of practice for overhead traveling Crane and Gantry crane other than steel work crane.

IS:2365 steel wire suspension ropes for lifts elevators and hoists.

IS:807 code of practice for design, manufacture, erection & testing of crane and hoists.

IS:3443 crane rail section.

IS:3815 point hook with shanks for general Engineering purpose.

IS:800 code of practice for use of structural steel in general building structure.

IS:2062 weldable structural steel.

IS:3681 spur and helical gears.

IS:3734 dimensions for worm gearing.

IS:1364 precision and semi-precision, hexagonal bolts, screws, nuts and locknuts.

IS:816 code of practice for use of metal arc welding for general construction in mild steels.

IS:1181 qualifying test for metal arc welders.

IS:1323 code of practice for oxy-acetylene welding for structural work.

IS:3961 recommended current rating of cables.

IS:282 hard drawn copper conductors for overhead power transmission.

IS:2147 degree of protection provided by enclosures for L.V. switchgear and control gear.

IS:2959 contactors for voltage not exceeding 1000V AC or 1200V DC.

IS:2208 HRC cartridge fuse links for voltage above 650V.

IS:4047 heavy duty air break switches not exceeding 1000V.

IS: 5749 forged rams horn hooks.
The material of various components shall be in accordance with relevant IS or equivalent international standard.

3.0 GENERAL DESIGN REQUIREMENTS:

Whole supply & erection shall conform to the following standards and specifications except as modified herein:

The Vendor shall be responsible for complying with any other statutory requirements governing the work.

DESIGN OF MECHANISM

For the hoist mechanism of cranes electric motor shall be connected to the reducer through floating shaft and half geared couplings. Coupling of the output shaft of the reducer to single or double drum shall be by means of geared coupling.

BEARINGS

All running shafts and wheels running on fixed axle shall be fitted with sealed antifriction ball or roller bearings.

COUPLINGS

1. All couplings shall be gear couplings, except that rigid coupling may be used on long transmission shafts.

2. All couplings shall be of steel. Cast Iron shall not be used.

GEARINGS

All gear boxes shall be in totally enclosed construction and gears shall be spur or helical type with machine cut teeth suitably hardened and tempered and shall conform to AGMA standard. The surface hardness of pinion shall be between 255 to 300 BHN and for gear 217 to 255 BHN. Difference in hardness of pinion and gear must not be less than 20 BHN.

For Accurate fixing of unit mechanism (reducer, brakes, motor etc.) and as well as to exclude the possibility of misalignment while working, support surfaces shall be machined level.

TRACK WHEELS

In case where crane and trolley have more than four wheels, balancers shall be used.
The body of the balancer may be fabricated from steel plates or from cast steel.

BRAKES
Hoisting Motion: - The brake shall be automatic electro-mechanical or thrusters release brake applied directly to the hoist motor shaft.

Traversing Motion: - The traversing motion (CT) of every electric overhead travelling crane shall be fitted with an automatic electro-mechanical brake irrespective of traversing speed.

Capacity of hoist brakes shall be determined as follows:

\[ Mt = K \cdot M_{ct} \text{Kg-m} \]

where,

\[ M_{ct} = \text{Static Moment on the braking shaft, due to action of the load, considering the maximum efficiency of the mechanism.} \]

\[ K = \text{Co-efficient of reserve of braking, taking from following figures, corresponding to the class of duty of the mechanism.} \]

For light duty (Class I) \( K = 1.5 \)
Medium duty (Class II) \( K = 1.75 \)
Heavy duty (Class III) \( K = 2.0 \)

Manufacturer to consider Heavy duty co-efficient (K=2.0) of reserve of braking and shall be compliant to IS: 3177.

In case of hoist mechanism with two drives, each drive must have at least one brake. Co-efficient of reserve of braking of each brake is taken not less than 1.25, considering that the full load can be held by one brake.

In case where two brakes are used for each of the two drives co-efficient of reserve of braking must not be less than 1.1 for each brake.

Required capacity of braking in case of traverse and travel motions shall be 0.8 – 1.0 times the static moment on the respective braking shafts due to action of inertial forces, considering maximum efficiency of the mechanism.

Brake drums shall preferably be made of steel castings or steel forging.

HOOKS

Hooks shall conform to the relevant Standards.
The crane hooks shall be provided with spring loaded safety locking arrangement.

No repair work on hook made to shall be allowed without prior approval from purchaser.

MEANS OF ACCESS

Platforms: - An adequately guarded platform minimum 750 mm wide shall be provided on both sides for the full length of the bridge. All platforms and ladders shall have non-skid chequered plate treads and shall be provided with handrails and toe guards. Opening on guard railings for access from outside shall be provided with safety chains.
The access ladder to EOT assembly from G.L. shall be suitably located avoiding any hindrance to EOT travel.
LUBRICATION

All the grease points shall be brought to a safe and easily accessible place which shall be prominently displayed. All gear boxes shall be fully enclosed type prohibiting ingestion of outside dust, oil and moisture. Gear shall be compliant to AGMA/ IS:4460. There will be no centralised lubrication system.

BUFFERS

Bridge of crane and trolley shall be provided with buffers for soft dashing with end Stop. Buffers ends should be made of rubber or iron & wood.

Welding: Welding shall be in accordance with relevant Standards.

ELECTRICAL DESIGN

All electrical including electro-magnetic brakes, limit switches, cables, wirings, lightings etc. shall be in accordance with the Electrical Specifications enclosed.

4.0 SPECIFIC DESIGN REQUIREMENTS:

The Cranes shall be suitable for the duty conditions as given in the specifications sheets.

4.01 Material of construction must be well proven for the required services.

4.02 Cranes shall be suitable for outdoor installation but placed under the roof.

4.03 All gear boxes shall be fully enclosed type.

4.04 The rail and roller support for the flexible cable shall be designed for maximum reliability and minimum maintenance requirements. The roller supports shall be interconnected by flexible steel wire in order to protect the flexible cables against mechanical stress. DSL trolleys shall be provided with four wheels. Rollers should not require greasing.

4.05 Mechanical safety lowering brake shall be supplied by the Vendor which shall be capable of holding the test load in addition to electro hydraulic thrusters brake for all the hoisting motions.

4.06 The Vendor shall provide non-sparking type aluminium guards for couplings.

4.07 The Vendor shall, if required, provide a clearance certificate from a Competent Authority regarding following the safety rules and regulations.

4.08 All the Bearings shall be antifriction type. Bush Bearings are not acceptable.

4.09 1 No. rotary type and 1 No. gravity type limit switches will be provided for each crane/ hoist.
4.10 2 Nos. one way lever type limit switch will be provided for trolley and 1 No. anti-collision device and 1 No. one way type limit switch will be provided for LT.

Anti collision device will consist of 1 No. one way lever type limit switch and striker arm.

4.11 Micro speed arrangement on main hoist, CT and LT will be achieved through separate sq. cage motors, 1 No. thruster brake and planetary gear box arrangement.

4.12 **Installation**

The cranes shall be placed on rails at an suitable elevation of equipment/train building and shall be operated from pendant push-button boxes.

The flexible supply cables shall allow operation of the cranes in the full length of the equipment/train building.

---

5.0 **BATTERY LIMITS**

The following items are excluded from the supply from EOT Crane Manufacturer:

- Building structure including beams supporting crane rails.
- Gangways and ladders along building walls.
- Earth connection to gantry rails.

5.1 It is the obligation of the vendor / OEM to ensure supply of complete package of EOT Crane.

5.2 However, all requisite regarding supply, erection, commissioning covering wide spectrum of project shall be LSTK Contractor’s responsibility.

---

6.0 **EXTENT OF SUPPLY & ERECTION**

6.1 **General**

Supply includes Design, calculations and all materials and services needed for satisfactory and safe operation of the cranes including:

- erection on site
- pre-commissioning and start-up
- load testing which will be performed after erection.

6.2 The supply shall include but not be limited to:-

6.2.1 Design, engineering and fabrication.

6.2.2 The electrical equipment including isolator, flexible feeder cables/internal connection and the control system as per electrical specifications.
6.2.3 The roller supports, fixing material and rails for flexible supply cables.

6.2.4 Crane rails including support plates, cleats, etc. and electrical inter-connections for earthing of rails.

6.2.5 Mechanical stops and buffers for LT & CT motions.

6.2.6 Gangways and steps on the cranes but not on the building.

6.2.7 Workshop tests according to Clause No. 7.0

6.2.8 Painting according to brief specification as described in Article 9.0

6.2.9 The documentation in accordance with NIT/ITB.

6.2.10 The spare parts for 2 years operation as per NIT/ITB.

6.2.11 Inspection programme as per Clause No. 7.0

6.2.12 The name plate in the English Language with indication of max. Permissible load.

6.2.13 Alignment of sole plates, erection and alignment of rails, and down shop leads including supporting arrangement for DSL, wherever required.

7.0 INSPECTION, TESTING & REPAIRS

7.1 Inspection & Testing programme shall be furnished by the Vendor after placement of order for OWNER’S approval.

7.2 Inspection and testing shall conform to relevant standards.

Parts found defective or not conforming to the Standards as to workmanship or materials shall be rejected and replaced by the Vendor free of cost.

Waiving of inspection or acceptance of material or equivalent by the purchaser shall not relieve the manufacturer from the responsibility of furnishing material or workmanship in accordance with the relevant Standards.

All welding shall be carried out by qualified welders. Manufacturer shall furnish evidence acceptable to Third party Inspector of qualification tests of welders as required by relevant Indian Standards. All welding shall be subject to inspection by TPI, who will have the option to call for radiography or other non-destructive examination of welds to check soundness.

The main bridge girder shall be completely radiographed and radiographs produced. However, butt welds of bridge girder will be 100% radiographically tested on tension zone and 25% at random on compression zone.
7.3 **TESTS AT MANUFACTURER’S WORKS**

All electrical and mechanical equipment shall be tested in accordance with the appropriate Standards at either the crane maker’s or the equipment manufacturer’s works and test certifications shall be furnished.

The cranes shall be tested at manufacturer’s works under no-load. Travelling gear may be run light to check shaft and gear alignments.

**TESTS AT SITE**

For testing of electrical installation, refer Electrical Specification.

**Test for Operation:**

After the supply has been connected, and before the complete crane installation is put into commercial service, tests shall be carried out to prove the following:

- Satisfactory operation of all motors under no-load conditions.
- The satisfactory operation of each controller, switches contractor, relay and other control devices and in particular the correct operation of all limit switches under the most unfavourable conditions:
  - The correctness of all circuits and interlocks and sequence of operation.
  - The satisfactory operation of all protective devices:
  - The satisfactory operation of each motion of the cranes.
  - The compliance of the crane with the specified performance requirements: and
  - Tolerance on specified speeds at full load shall be with $\pm 10\%$.

7.4 **DEFLECTION TESTS:**

The deflection test shall be carried out at site with the safe working load at rest and with the crab in a central position. The measurement shall not be taken on the first application of the load. The datum line for measuring the deflection shall be obtained by placing the crab on the extreme end of the crane span with smaller hook approach.

7.5 **OVERLOAD TESTS:**

After tests but before the crane is put into service, it shall, with overload relays approximately set, be tested to lift and sustain a minimum test load of as per codes & standards requirement.

During the overload test each motion in turn shall be manoeuvred in both directions and the crane shall sustain the load under full control. The specified speeds need not be attained but the crane shall show itself capable of dealing with the overload without difficulty.

8.0 **PREPARATION FOR SHIPMENT**

8.1 Each transport unit shall be suitably prepared for shipment, properly braced and loose parts secured to prevent damage during shipment. All material
shipped shall be properly marked with the item number for which it is intended by means of a metal tag.

8.2 The vendor shall give all information concerning the protection needed for preservation of the equipment.

9.0 **PAINTING**
Painting shall be as per manufacturer standard and appropriately chosen for owner’s site condition.

10.0 **SPARES**

10.1 All erection, pre-commissioning & commissioning spares including spares consumed during testing / PGTR till handing over the plant to owner shall be supplied by LSTK Contractor free of cost. Any unused commissioning spares shall be owner’s property.

10.2 Mandatory spares shall be supplied by the LSTK contractor as per NIT.

10.3 LSTK Contractor to also furnish separate recommended list of 2 years operation & maintenance spare part list along with budgetary offers, valid for 2 years from the date of submission of offer for owner’s consideration.

   Recommended spares and their quantities should take into account related factors of equipment reliability, effect of equipment downtime upon production or safety, cost of parts and availability of vendor’s service facilities around the proposed location of equipment.

10.4 Detail List of special tools & tackles shall be furnished by the LSTK bidder along with the bid and shall be in scope of supply of the LSTK contractor.

11.0 **DRAWINGS AND DOCUMENTS:**
The drawings, documents and data to be supplied after placement of the order shall be as per NIT.

12.0 **GUARANTEE:**
The crane shall be guaranteed by the supplier to be of accepted design, free from inherent defects in either workmanship or materials and to safely handle its rated capacity load without any undue deflections on its structure or mechanism. Any part proving defective within the warranty period shall be replaced free of charge by the Vendor.

12.1 **Performance Guarantee:**
The cranes with its drives and other equipment shall be tested at site to verify the electric consumption, various speeds, deflection and other performance figures guaranteed by the Vendor. Noise levels at 1.0 M distance from package machine’s surface shall not exceed 85 d B(A).

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<td>The Sub vendor / manufacturer/ Supplier must have supplied similar model, size for two similar installations &amp; service which are working satisfactorily. Feed Back report for the same shall be furnished to Owner / PMC prior to placement of order.</td>
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SECTION : VI- 5.4

DESIGN PHILOSOPHY- ELECTRICAL

PLANT : STEAM GENERATION PLANT

PROJECT : INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA)
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1.0 SCOPE

1.1 The scope includes work/service for the complete design, engineering, manufacture, testing at works, supply of all electrical equipment, dispatch, storage, handling, erection, testing at site and commissioning of complete electrical system required for ‘Steam Generation Plant along with its Associated Utility facilities’.

Although every item of supply and/or installation might not have been described, the LSTK Contractor shall supply anything and everything to complete the project.

1.2 This specification shall be read in conjunction with all drawings and documents attached and other relevant reference as specified therein.

1.3 The scope of work/services of LSTK Contractor shall comprise complete electrics of the Steam Generation Plant along with its Associated Utility facilities. The scope of work/services shall broadly comprise but not limited to the following:

1.2.1 Design & detailed engineering, Coordination, General Services etc

a. Basic as well as detailed engineering.

b. Preparation of drawings/document to suit Project implementation schedule. Preparation of drawings/documents/calculations/formats/test reports/test certificates; Erection, Testing & Commission Manuals/Operations & maintenance Manuals/Reports/QAP etc for approval/Review/reference/record and/or for any other requirement; submission to Owner/Consultant in requisite sets, getting approval from Owner/Consultant, making approved copies available to manufacturers, inspectors, erection & commissioning engineers, supervisors, owner/Consultant etc as required in requisite sets well before those are actually required by them to fulfill their obligations.

c. Design, manufacture, testing of equipment/cables/cable trays/earthing and other erection materials etc at manufacturer’s works, submission of documents with manufacturer's test reports/type test reports to Owner/Consultant prior to inspection call.

d. Quality Assurance at each stage of manufacture including procurement of raw materials/bought out items and arranging inspections by Owner/Consultant/third party.

e. Obtaining dispatch clearance from Owner in writing.

f. Packing, loading, forwarding, delivery at site/store, loading/unloading, storage as per manufacturer's recommendation; shifting from stores and handling in store as well as at site for erection.

h. Arrangement of testing/checking instruments/kits/sets/apparatus with valid calibration certificates issued by duly accredited laboratories/institutions, to carry out tests stipulated in specification and documents referred therein/other applicable standards.

i. Deputing electrical contractors, supervisors' electricians, cable jointers etc. on full time basis for carrying out electrical work.

j. Conducting pre-energisation tests to ensure that installation is fit to be energized.

k. Erection shall not be considered complete unless pre-energisation tests are carried out, results are tabulated & submitted to owner/consultant and results are found satisfactory.

l. Conducting functional/pre-commissioning checks/Cold trial runs; no-load & load tests,

m. Commissioning the installation.

n. Conducting Performance Guarantee tests and taking corrective steps (inclusive of replacement of equipment/materials if required) till results are satisfactory/acceptable.

o. Conducting Pre-Acceptance Tests/checks and tabulating the results/observations
p. Liquidations of defects/ discrepancies/ observations noted during erection, pre-
energisation tests, commissioning, trial runs, performance guarantee tests, Pre-
acceptance tests/ checks etc.

q. Submissions of all final/ ‘As built’ drawings/ documents after incorporation of changes
made in soft as well as hard copies, duly certified by LSTK Contractor to the effect that
those are ‘Final’ and/ or ‘As built’

r. Conducting Final Acceptance Tests/ Checks

s. Co-ordinate with the Owner/ Consultant, other contractors/ agencies working at site as
required for proper, smooth and timely execution of work/ implementation of the project
t. Preparation of drawings/ documents, applications for getting the installation inspected
and approved by Electrical Inspectorate of state and/ or Central Electricity Authority and
all coordination for getting the installation approved for energisation & use. Carrying out
all modifications/ alterations required by statutory authorities. All expenses on these
activities shall be carried out and borne by LSTK Contractor. The obligation of owner
shall be limited to
  − Signing of application as owner of installation and
  − Payment of fee for inspection of installation.

Approved drawings and certificates shall be submitted to the Owner/Consultants well
ahead of schedule so that the actual commissioning of equipment does not get delayed
for want of inspection and approval by the Electrical Inspectorate and other statutory
bodies. The actual inspection work by the Electrical Inspector shall be arranged by the
LSTK Contractor and necessary coordination and liaison work in this regard shall be the
responsibility of the LSTK Contractor.

1.2.2 Manufacture, testing at works, getting inspected by owner and/ or their consultant/ third
party, packing, transportation and delivery to site in well packed condition, insurance during
transit and till commissioning & handing over, storing at site as per recommendation of
manufacturer/ supplier/ direction of supervising engineer of Owner/ Consultant until required
for erection, transportation to work place. Erection, testing & commissioning, handing over of
complete electrical system of ‘Steam Generation Plant’ (hereinafter referred as Plant in
short) comprising, but not limited to :
a. Boiler Control panels and all electrics associated with the boilers and associated
   systems.

b. Emergency DG sets including automatic mains failure (AMF) panels to meet all
   emergency and essential loads of Plant, including providing power to all auxiliaries for
   emergency shutdown.
   All DG Sets shall have provision for Black Start condition.

c. Bus Ducts
d. Transformers viz.
   − 11/3.45 , 11/0.433 kV, 3.3./0.433 V Transformers, as required
   − Lighting Transformers
e. Switchgears:
   − 11 kV / 3.3 kV ICOG Panel, as required
   − 11 kV Switchgears/ switchboards, as required.
   − 3.3 kV Switchgears/ switchboards, as required.
   − DG power Distribution Board.
- 415 Volt Switchgears/ switchboards including PCCs, PMCCs, MCCs, EPMCCs MLDBs, ASPBs, LSDB, PDB, Junction boxes etc. as required.
  - Local control Panels, Local Control stations, Switch Sockets.
  - Variable Frequency Drive Panels, as required.

f. 11kV, 3.3kV, 415V Motors and other special application/ voltage motors as required.

g. All Cables viz
  - Power Cables (11kV, 3.3kV and 1.1kV)
  - Control Cables,
  - Earthing Cable
  - Signal cables,
  - Optical fibre cables
  - Data Cables
  - Communication cables
  - Special application cables

h. Erection/ installation & all sundry materials for installation, testing & commissioning of equipment/ panels/ fittings/ cables (including jointing & termination of cables) comprising (but not limited to) following:
  - Foundations,
  - Brackets, support structures, erection materials & accessories, as required
  - Cable trays, racks, pipes, ducts, cable channels etc as required.
  - Testing checking kits/ instruments

i. Illumination system - Normal, emergency and evacuation lighting

j. Aviation lighting

k. Neutral grounding, NER.

l. Earthing and equi-potential bonding of equipment & structures.

m. Protection against lightning.

n. 110V DC Batteries, battery chargers and DC distribution boards as required.

o. 115V AC UPS System with batteries & UPS Power Distribution Boards for Instrument.

p. 240V AC UPS Panels with batteries & UPS Power Distribution Boards for Electrical

q. Complete Electrics for Boilers/ steam generating units, turbines with auxiliaries.


s. Complete Electrics for Air Conditioning and Ventilation systems.

t. Complete Electrics for Chemical Dosing System

u. Complete Electrics for fire fighting system, 


w. Plant Communication system

x. Cathodic Protection System.

z. Public Address System for Plant and Hook-up of same with Centralised Public Address System.

aa. Fire Detection & Alarm System for Plant and Hookup of same with Centralised Fire Detection & Alarm System.

bb. Cable trench/Cable tray with supporting structure.

cc. Fire fighting systems for Electrical Equipment/ Panels by gas flooding.

dd. The scope shall also include the erection, testing, commissioning of above equipments.

The contractor shall clear the site after commissioning of the equipments / system and obtain the Site Clearance Certificate from owner’s Engineer-in-charge

e. Any and all other Materials, Equipment and Services so as to make a totally integrated and functional system together with all accessories and associated equipment, ensuring safety, maintainability and reliability in compliance with all applicable codes, standards, guidelines, statutory regulations and safety requirements in force.

ff. Any other equipment, not specified, but required for safe, proper, trouble free and efficient operation of the system

gg. LSTK Contractor shall consider any other requirement which is not covered in this NIT, but required for successful operation of the plant.

hh. Spares & consumables for complete electrics as follows:

- Commissioning Spares (as per Clause No. 20.0 of Design Philosophy-Electrical) and Spares for 2 Years operation (Mandatory/Insurance) for all equipments (as per Section 10.0: Spare Parts) shall be supplied by the Contractor as part of LSTK contract.

- LSTK Contractor shall recommend 2 years Operational Spares for all the equipment (item-wise) with recommended quantity & unit price with validity of 2 Years. The same shall not be part of LSTK price.

- Spares and consumables required and first oil fills including short fall during erection, testing, cold trials, commissioning, performance evaluation tests, guarantee tests etc and till handing over of installation.

ii. Tools & Tackles.

jj. Testing Equipments/ instruments

kk. Arranging services of major equipment suppliers during installation and commissioning.

ll. Training of Owner’s Personnel for Operation & maintenance of the Plant.

mm. Any and all other items/ facilities/ services not specifically mentioned but essential/ required for completeness of the systems/ equipments/ facilities

1.4 Normal power supply shall be tapped from two numbers of 11KV feeders at Owner’s Main Receiving substation and further distribution shall be in LSTK Contractor’s scope.

For Emergency power LSTK Contractor shall provide DG System complete in all respect alongwith DG Power Distribution Board. However, Bidder shall indicate the details of Emergency Loads in the bid.

1.5 This design philosophy contains specifications of the major equipments to indicate the basic requirement and serve as a guideline. However, it shall be the responsibility of the contractor to offer a complete quality electrical system of superior quality, even if the specifications of certain items are not given. The items for which technical specifications are not indicated herein shall be of IS/IEC standard and specifications of these shall be subject to owner’s approval in case of order.
1.6 The bidder shall offer the best and proven most suitable type of energy efficient equipments manufactured by well known reputed manufacturers having proven performance track record of minimum 2 years, as per vendor list appended in this bid package. However for the sake of standardization of the electrical equipment and material used for the electrical installation, the LSTK Contractor shall supply all items of a particular type or make for whole plant of the same manufacturing company for ease of maintenance and less spares inventory.

1.7 1 No. 11 kV Feeder (rated for 2 MVA) at Existing Substation near 132 KV Switchyard shall be made available for Construction Power. Tapping of Construction Power (on chargeable basis) from this feeder (including supply & erection of all required materials like structural supports for cable tray, cable trays, power cables, control cables, protection & metering, cable termination etc. as well as underground cabling work) and further distribution shall be in LSTK Contractor's scope.

Bidder shall ensure that the minimum power factor of 0.9 shall be maintained at their end by providing suitable power factor improvement devices.

LSTK contractor shall have to distribute construction power with adequately rated distribution and sub distribution boards/feeder pillars, power supply cables and other associated materials for feeding loads to carry out construction and fabrication activities at his own cost.

Bidder shall indicate details of construction power in the bid with month-wise breakup for the entire duration of project.

However during non availability of construction power, LSTK contractor shall have to arrange emergency power, if required, through DG set at their own cost.

1.8 Contractor shall provide adequate area lighting at site of construction, fabrication yards, storage yard and office etc. by means of suitable lighting fixture, lighting masts, flood lighting poles etc. which are to be supplied and maintained by the contractor as per safety aspect.

1.9 Electrical system studies like Load Flow Study, Short Circuit Study/Electrical Fault Analysis, System Stability Studies under transient and steady state condition, Motor Starting Study, Relay Co-ordination & Relay Settings, Overvoltage study etc. of the entire electrical installation of ‘Steam Generation Plant shall be conducted by the LSTK Contractor using latest software preferably ETAP at appropriate stage of design-engineering. Same shall be done by the reputed and well established Third Party and Electrical equipment of Plant shall be designed and selected accordingly.

All the Electrical equipments shall be designed and selected according to the Short Circuit Study Report.

LSTK Contractor shall submit the study Report in two stages i.e. preliminary and final along with all the necessary calculation for Owner/Consultant’s approval/comments. All equipment Rating to be finalised only after necessary approval and supply / modification in any equipment shall be done accordingly without any cost and time implication.

LSTK Contractor shall provide all editable ETAP working files latest version with complete library/Backup, during design engineering as well as after completion of project. Also, LSTK Contractor shall explain the complete ETAP Study in detail at Owner/Consultant’ office upto their full satisfaction.

In case equipment is ordered before studies are completed and revision of rating or design is required as a result of study then inclusion of such revisions shall be in LSTK Contractor’s scope without any cost and time implication.

Final ETAP editable file along with library and base files and final ETAP study Report shall be provided by the LSTK Contractor.

1.10 For control, monitoring, load management, data logging and printing of status of all important electrical equipment and feeders, a Programmable Logic Controller (PLC) based Load Management System (LMS) shall be provided by Electrical Distribution System (EDS) LSTK Contractor. However, LSTK Contractor has to provide the required multifunctional dual
channel transducers (Only where Current Data is critical and used in process control), Digital Multi-function Meters, latest version numerical/Communicable type protective relays with non-volatile memory, comprehensive unit providing protection, metering, control & communication with communication port & interlinked with Online Energy/Load Management System and required microprocessor based devices if any in panels, communicable door mounted Motor Protection Relays in all motor feeders of PMCC & MCC, proper communication facility in supplied UPS, Battery Chargers, VFD, Soft starter, DG sets, MOV and other critical equipment for proper communication with LMS / DCS system. The interface of electrical equipments with LMS / DCS shall be through IEC 61850 communication protocol for Numerical relays and IEC 61850/Modbus for Multifunction Digital Meters, Motor Protection Relay (MPR) and other equipment, Ethernet communication module shall also be used. 100% redundancy shall be provided for communication i.e. the relay should have minimum 2 Nos. IEC-61850 communication port in addition to Front Port.

LSTK Contractor shall provide separate room for local LMS equipments (Data Concentrator Panels, OWS, EWS, PC console, chairs, furniture etc.) in substations of Steam Generation Plant. Provision of future expansion of Data Concentrator Panels etc. shall also be considered while designing separate room.

1.11 The scope shall also include obtaining all required statutory approvals from all statutory bodies. Contractor shall carry out all modifications/alterations required by statutory bodies. All approvals for permanent installations shall be obtained in the name of Owner. Approval for equipment & installation for Construction Power shall be in LSTK Contractor’s name.

1.12 In case of any discrepancies between Design Philosophy – Electrical and Technical Specification of equipment/item/work in respect of description of equipment/item/work, the details indicated in the Design Philosophy – Electrical shall prevail.

1.13 Final location of equipments as well as route of cable trays shall be rechecked in 3D modelling.

1.14 All electrical equipments installed in the areas classified as hazardous shall be certified for such use by a recognized certifying authority such as CIMFR Dhanbad / PESO, Nagpur etc.

1.15 All electrical works associated with the followings but not limited to, shall be considered

a) Steam generating unit  
b) Fuel oil system  
c) Turbine oil purification systems  
d) Piping valves and specialties  
e) Ventilation system  
f) Coal Handling System, Limestone Handling System  
g) Ash handling system including dry fly ash storage silo area auxiliaries etc. including ESP (Electro Static Precipitator) .  
h) Air conditioning systems  
i) Chemical Dosing System.  
j) Fire fighting system,  
k) Fire protection system  
l) Diesel generator sets  
m) Cranes, Hoist, elevators/Industrial Goods Lifts  
n) Pollution control and monitoring equipment  
o) Stack  
p) All auxiliary building & associated electrical building/rooms.

1.16 Following Integrations are envisaged presently in scope of LSTK Contractor;

- Protection for outgoing feeder of 11 kV Switchboard at Main Receiving Substation to LSTK Contractor Switchboard (Inter tripping, Cable Protection etc.
- Hook-up and Seamless Integration with Centralised Fire Detection & Alarm System.
- Hook-up and Seamless Integration of Centralised PA System.
However, any other interface and Seamless Integration requirement or any other unforeseen which may arise during detailed engineering/execution stage, same shall also be in the LSTK Contractor’s scope without any cost and time implication.

1.17 All the substations shall be provided with following equipment:

- CO₂ fire extinguishers (4.5 litre capacity) as per applicable NFPA.
- Synthetic insulating mats on front and back side of the switchboards. (LV as well as HV) as per latest IS.
- Framed single line diagram in Aluminium frame with glass.
- Do’s & Don’t chart as per Indian Electricity Rules in Aluminium frame with glass.
- Shock treatment chart written in English and Local language duly framed and approved by engineer-in-charge.
- Caution boards / dangers boards written in ENGLISH & HINDI for all the voltage levels.
- CPR (CARDIO PULMONARY RESUSCITATION) Charts.
- High Voltage / Low Voltage danger signage (Skull & bones).
- Exit Route / Emergency Exit Route Signage.
- Earthing rod.- Minimum 1 No. for each Voltage level.
- Sets of Sand buckets with stand (each with at least 3 sand buckets) for substations and transformer yards.
- HT discharge rod.
- HT and LT hand Gloves (3 Sets each for each substation).
- A Type FRP ladder 3 feet & 8 feet – 2 no each type for each substations.
- First Aid Box

Other requirement or any other unforeseen which may arise during detailed engineering shall also be in LSTK Contractor’s scope

2.0 BASIS OF DESIGN

2.1 General

2.1.1 The electrical installation shall be designed to provide:

- Necessary amount of power
- Flexibility
- Service reliability
- Ease of expansion
- Ease of operation and maintenance & inter changeability of equipment
- Safety of personnel

The design of electrical installation shall ensure provision of a safe, efficient and reliable supply of electricity at all times including adverse system conditions. Safe conditions shall be ensured under all operating conditions including those associated with start up and shut down of plant as well as those arising out of failure of electrical equipment. The isolation of part of system of electrical equipment due to either maintenance or shut down shall not compromise safety aspects.

2.1.2 The design of electrical installation shall ensure provision of a safe and reliable supply of electricity at all times. Safe conditions shall be ensured under all operating conditions including those associated with start up and shut down of plant as well as those arising out of failure of electrical equipment, climatic conditions like lightning and earthquake etc. The isolation of part of system of electrical equipment due to either maintenance or shut down shall not compromise safety. All electrical equipments shall be of proven design and technology.

System shall be designed considering following aspects in general:
To facilitate inspection, cleaning and maintenance with the care to safety in operation and personnel protection.

To minimize turnaround time.

To provide safety, reliability and flexibility of service.

Adequate provision for future extension and modification.

Maximum interchangeability of equipment.

Desired level of operator interface to achieve coordinated efficient and fail-safe operation, data logging and maintenance of the equipment.

To decide redundancy, stand by, spares and overload capacities to achieve desired reliability and flexibility requirement.

To get cost effective and techno commercially proven technology. Economic considerations shall cover capital and running costs and an assessment of the reliability of the system.

2.1.3 All the electrical consumers within the battery limit shall be identified and listed to have complete details of rating, efficiency, power factor, operating duty cycle (continuous, intermittent, standby), category of supply required (emergency, normal, critical) etc.

2.1.4 Required redundancy (based on specific process/operating needs) shall be built in substation which feeds power supply to process units/important facilities so that in case of tripping of one feeder, the unit may not be adversely affected and continuity in operation at full capacity is achieved.

2.1.5 While sizing the system necessary consideration shall be given to restrict the system voltage drop within permissible limits during starting of large rated motors. At the same time, the short circuit current shall be kept within limits keeping in view of the market availability of switchgears rating. For this purpose current limiting reactors/unit ratio transformers if required may be used.

2.1.6 LSTK contractor while performing design and engineering activities shall adhere to following guidelines.

a) If any equipment is not covered in this design philosophy but required for successful operation of the project, LSTK contractor shall prepare additional specifications for equipment or bulk material taking reference of Indian/International Codes and good engineering practices prevalent in fertilizer industry and obtain owner’s approval for the same.

b) The standard drawings attached with this package define the basic system design and distribution philosophy for the package. This is for guidance purpose only. LSTK contractor shall develop detailed drawings and submit for owner’s approval.

c) LSTK contractor shall be responsible to verify the rating and consider providing equipment with adequate rating but not less than the specified rating. Compliance should be without any extra cost and time implications.

d) LSTK contractor shall consider any other requirement which is not covered in this bid package, but required for successful operation of the plants without any extra cost and time implications.

e) Contractor shall obtain approval from all statutory authorities such as Central Electricity Authority (CEA)/Electrical Inspectorate, Chief Controller of Explosives (CCoE), CPCB etc. for all electrical facilities including electrical switchboards & panels supplied and installed by LSTK contractor.

f) LSTK contractor shall assist in Liaison and in all interface coordination with contractors of other units of project at construction, erection, testing & commissioning phase for any common facility and for smooth execution.

g) Equipment specification sheet/data sheets for all equipment shall be prepared by the contractor based on relevant codes and Technical specifications/ Data sheets attached.
as reference. Data sheet shall contain all technical data and information which are essential for review and technical acceptability, detailed engineering, installation, testing, repair and maintenance, replacement etc.

h) Contractor shall clearly specify in their purchase specifications the requirement of conducting special tests/type tests, which are envisaged for various electrical equipment which shall have no impact on cost and time.

i) Bidder shall must visit the site and collect all relevant information required for designing of complete system before quoting. Bidder shall make themselves familiar with the work actually involved and actual site conditions. Failure to do so shall not absolve the Bidder of their responsibilities based on adverse site conditions.

j) All the electrical equipments shall be of proven design and technology.

k) Normal & Emergency Load details (rating of all motor, Lighting, Switch socket etc.) load shall be submitted.

l) If VFD is provided in BFW Pump and FD/ID Fans, There shall be provision for by-pass facility. It shall be possible to start the motors in DOL mode through by-pass system in case there is any problem/fault in the VFD. The Electrical system and the process design should have necessary provision to start & operate the Motors in fixed speed (without VFD) without affecting the normal operation of the Boilers.

m) Load Summary shall be prepared by LSTK contractor to determine ratings of electrical equipments (DG set, transformer, switchgears, cables etc.), to evenly distribute plant loads among the various substations and switchgear, and to evaluate the need for power factor correction. All calculation shall be necessarily reviewed/approved by Owner/Consultant.

Motors, heaters etc. shall be designed as per Section 4.0: Design Basis of NIT.

The maximum normal running load and the peak load shall be calculated as follows:
Maximum Normal Running Load = (100% of sum of all continuous load) + (40% of sum of all intermittent loads or largest intermittent load, whichever is higher).

Peak Load = (100% of sum of all continuous load) + (40% of sum of all intermittent loads or largest intermittent load, whichever is higher) + (20% of sum of all standby loads or largest standby load, whichever is higher).

Electrical System shall be designed for continuous Peak Load operation.

Note: If electrical motor is stand-by to non-electrical driven equipment (for e.g. turbine driven equipment), then in such case standby motor shall be considered as continuous load.

All the electrical equipments shall be designed / sized considering motor input power (i.e. BKW divided by motor efficiency).

Margin for future requirement shall be as per clause 2.1.6 n over the above.

Line loss of 2% to be considered for equipment sizing.

Minimum P.F. shall be maintained as 0.95 at every voltage level.

All the electrical equipments like Transformers, DG Set, Switchboards etc. shall be suitable for starting of the largest motor, while other loads are running, considering peak load condition.

n) Electrical equipments i.e. DG Set, Transformers, Switchgears, MCCs, PCCs etc. shall have capacity for future requirements. The Margin shall be as follows:

i) DG Set sizing: 25% is added to the Maximum Emergency Load.

ii) HV Transformer: 25% is added to the Continuous Peak Load.

LV Transformer: 30% is added to the Continuous Peak Load.

iii) Switchgear: Switchgear bus bar current rating as well as breaker shall be equivalent (nearer or higher standard rating size) to full load current of upstream Transformer.
iv) Switchboards and MCCs fed from other switchboards: Shall be rated for 125% of peak load.

o) The actual fault levels shall be arrived at on the basis of incoming power source, transformers, contribution of motors, etc.

p) Prospective touch and step voltages shall not be adverse to the stipulations of relevant publications of Bureau of Indian Standards / IEC/IEEE-80.

q) Sizing calculations for all the electrical equipments shall be submitted for review/approval, in case of award of order. Owner/Consultant’s Comments, if any on the same shall also be considered and modification in any equipment shall be done accordingly, without any price implication.

r) Seismic zone as applicable shall be considered for design of all electrical equipment.

2.2 Load Grouping

Electrical consumers shall be classified as 'normal / non-essential, emergency / essential or vital / critical' loads as per the concepts defined below:

2.2.1 'Emergency' or 'essential' loads shall be identified on the criteria that, when failing in operation or when failing if called upon, will affect the continuity of operation, the quality or the quantity of product. For such loads, reliable source shall be ensured. Such feeders shall be grouped on a separate bus section in the respective Switchboards/ MCCs / PCCs.

2.2.2 Some of the loads which can be identified as emergency / essential load but not essentially limited to following:

- Electrical loads required for continuous operation of process plants utility in case of normal supply failure.
- Electrical loads required for safe shut down of facilities in case of normal supply failure.
- Emergency lighting & communication facilities.
- Fire Detection and Alarm System.
- AC & DC UPS / Battery charging equipment.
- Control room AC equipment -Essential ventilation system for offices / Manned areas of other buildings.
- Motorised valves as per process requirement
- PA & Paging system.
- Barring gear
- AC Emergency Lub Oil Pump
- I.D. Fan Lub Oil Pump
- F.D. Fan Lub Oil Pump
- A.C. Seal Oil Pump
- Compressors
- Flame Scanner Cooling Air Fan
- Any other load (To be indicated by LSTK Contractor )

2.2.3 Critical' or 'vital' loads shall be identified on the criteria that, when failing in operation or when called upon, can cause an unsafe condition of the installation, jeopardize life or cause a major damage to the installation. For critical loads if any, UPS shall be provided to facilitate uninterrupted supply. The loads on UPS are AVR / PLC / DCS / Auxiliary supply for drives etc. Critical drives if any shall be provided with DC motors.

2.2.4 Some of the load which can be identified as critical / vital load but not essentially limited to following:

- Loads providing control and protection to plant equipment.
- Loads serving critical equipment for safety of plant, equipment and / or personnel
2.2.5 Non-essential service is a service, which is neither 'essential' nor 'vital'. Hence the non-essential load does not require any special measure such as standby feeder or standby source to safeguard the continuity of service.

2.3 **Statutory requirement Codes and Standards**

2.3.1 The design, installation, testing & commissioning shall conform to compliance of following statutory requirements:

- Indian Electricity Act
- Indian Electricity Rules
- The Indian Factories Act
- The Indian Explosives Act.
- Indian Boiler Regulation Act
- Statutory requirement of Govt of Odisha and Govt. of India.
- Guidelines, instructions, directions issued by Pollution control Boards of state as well as central government. Guidelines, instructions, directions issued by Chief Controller of Explosives (CCoE), CPCB, CMRI, DGMS, CEA etc.
- Guidelines of Tariff Advisory Committee
- Any other applicable Rules/Acts/Regulations.

The design, installation, testing & commissioning shall be in accordance with established codes, good engineering practices and latest versions of following documents valid/applicable on the date of acceptance of bid. The stipulations in these documents shall be considered as minimum requirements:

- Indian Standard Specification or equivalent IEC Standards
- Publications of IEEE
- API Standards
- National Electrical safety Code(NESC)
- Standards of Underwrites laboratory(UL)
- American Society for Testing Material (ASTM)
- American National Standards Institute (ANSI)
- Other International Standards

LSTK contractor shall be responsible for obtaining necessary statutory approvals from all the statutory bodies/authorities e.g. Electrical Inspectorate, PESO (earlier CCoE) as applicable before commissioning of electrical facilities. The CEA clearance for electrical equipment and components thereof shall be obtained by the contractor.

LSTK Contractor shall carry out all modifications / alterations required by all statutory bodies. However, necessary statutory fee shall be deposited by the Owner.

2.4 Some of the bare minimum relevant Indian Standards are as listed below. However, system/equipment design shall be in line with latest edition of all applicable standards.

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<tr>
<td>IS: 12459</td>
<td>Code of practice for fire protection of cable runs</td>
</tr>
<tr>
<td>IS: 12615</td>
<td>Energy efficient motors</td>
</tr>
<tr>
<td>IS: 13234</td>
<td>Guide for short circuit calculations</td>
</tr>
<tr>
<td>IS: 13346</td>
<td>General requirements for electrical apparatus for explosive gas atmosphere</td>
</tr>
<tr>
<td>IS: 13408</td>
<td>Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres</td>
</tr>
<tr>
<td>ISIEC: 60947</td>
<td>Low voltage switchgear and control gear</td>
</tr>
<tr>
<td>IS: 60034-5</td>
<td>Degree of protection provided by Integral design of rotating electrical machines</td>
</tr>
<tr>
<td>IS: 60079-0</td>
<td>Explosive atmospheres, Equipment General Requirements</td>
</tr>
<tr>
<td>IS: 60079-1</td>
<td>Explosive gas atmospheres – Part-1 Equipment protection by Flame proof enclosures “d”.</td>
</tr>
<tr>
<td>IS: 60079-7</td>
<td>Equipment protection by increased safety “e”</td>
</tr>
<tr>
<td>SP: 30</td>
<td>National Electrical Codes (NEC) - BIS Publication</td>
</tr>
<tr>
<td>IS/IEC 62271</td>
<td>HV Switchboard</td>
</tr>
<tr>
<td>IEC 60947</td>
<td>LV switchboard</td>
</tr>
<tr>
<td>IEC 61439-1/2</td>
<td>LV switchboard (PCC/PMCC/MCC) for TOTAL TYPE TESTED (TTA). Type Test Certificates for short circuit withstand of 50kA for 1 sec. along with ACB mounted in the Switchboards shall apply.</td>
</tr>
<tr>
<td>IEC 61641</td>
<td>Switch Board with INTERNAL ARC CONTAINMENT test</td>
</tr>
<tr>
<td>ANSI C-37:23</td>
<td>Metal enclosed bus</td>
</tr>
<tr>
<td>ANSI C-37:24</td>
<td>Effect of Solar radiation on metal enclosed bus</td>
</tr>
<tr>
<td>IEC 60034</td>
<td>Rotating Electrical Machinery</td>
</tr>
</tbody>
</table>
IEC 61131 Programmable controllers

IEC 60871-1 /IS 13925 Shunt Capacitors for AC power Systems Specifications

Any other standard may be followed provided it is equivalent or more stringent than the standards specified above.

2.5 In case of any conflict/deviation amongst various documents the order of precedence shall be as follows:

- Statutory rules/regulation
- Design Philosophy
- Data sheets
- Technical specification/Installation Standards, etc.
- Applicable IS/IES standards

In case of contradiction / conflict among documents and statutory requirement, LSTK Contractor shall refer to Owner for clarification. However, most stringent specification shall be followed with Owner’s approval. Owner decision shall be considered as final.

2.6 Site Conditions

The equipment shall be designed for the following site conditions:-

- Minimum ambient Temperature 1 deg.C
- Maximum ambient Temperature 46 deg.C
- Design Reference Temperature 50 deg.C
- Relative Humidity 100%
- Altitude above mean sea level Lower than 1000 Mtrs.
- Atmospheric pollution Dusty due to presence of Coal Dust & Urea Dust and corrosive due to presence vapours of Ammonia.

Equipment/ cables selected shall be derated for (a) higher ambient temperature, (b) restriction in temperature rise (c) variation in voltage, (d) variation in frequency (e) installation conditions viz. proximity to heat sources, bunching, layering, separation from others/ laying in conduits etc. with respect to the conditions for which it was designed & manufactured. Various de-rating factors considered shall be informed with supporting documents.

Equipment to be installed in MCC rooms/ Electrical Rooms/ Control rooms shall be designed for + 50° C so that in case of failure of Air-conditioning/ ventilation facilities, the operation/ functioning of equipment is not be affected.

3.0 AREA CLASSIFICATION.

3.1 The hazardous zones within the project area shall be classified according to the requirement of IS/IEC. The bidder shall furnish area classification drawing with Technical part of the Bid.

PESO approved Hazardous Area Classification Drawing shall be submitted during detailed engineering.

3.2 All electrical equipments installed in the areas classified as hazardous shall be certified for such use by a recognized international certifying authority such as CIMFR earlier CMRI, Dhanbad. The item shall in addition bear the valid certification from PESO (earlier CCoE) and also the manufacturer shall hold a valid Bureau of Indian Standards (BIS) license.
For those items where overseas OEM vendor will supply the electrical equipment certificate from international authority can be accepted but the certification shall be approved by PESO (earlier CCoE), Nagpur India.

3.3 The electrical equipment for hazardous areas shall be selected as per IS-5571 and petroleum rules and Gas group shall be selected based on the approved hazardous area classification drawing. The minimum requirement is summarized below:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Zone-1</th>
<th>Zone-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MV Motors</td>
<td>Ex-de</td>
<td>Ex-n</td>
</tr>
<tr>
<td>HV Motors</td>
<td>Ex-de / Ex-p</td>
<td>Ex-n/Ex-de/Ex-p</td>
</tr>
<tr>
<td>Push Button Station</td>
<td>Ex-d</td>
<td>Ex-d</td>
</tr>
<tr>
<td>Motor Starters</td>
<td>Ex-d</td>
<td>Ex-d</td>
</tr>
<tr>
<td>Plug &amp; Socket</td>
<td>Ex-d</td>
<td>Ex-d</td>
</tr>
<tr>
<td>Welding Receptacle</td>
<td>Ex-d</td>
<td>Ex-d</td>
</tr>
<tr>
<td>Lighting fitting</td>
<td>Ex-d</td>
<td>Ex-nR</td>
</tr>
<tr>
<td>Control Gear Box</td>
<td>Ex-d</td>
<td>Ex-nR/Ex-d</td>
</tr>
<tr>
<td>Junction Boxes</td>
<td>Ex-d</td>
<td>Ex-d</td>
</tr>
<tr>
<td>Transformer Unit</td>
<td>Ex-d</td>
<td>Ex-d</td>
</tr>
<tr>
<td>Break Glass Unit (Fire Alarm System)</td>
<td>Ex-d</td>
<td>Ex-d</td>
</tr>
<tr>
<td>Lighting Panel/Power Panel</td>
<td>Ex-d</td>
<td>Ex-d</td>
</tr>
</tbody>
</table>

**Notes:**

The electrical equipment for hazardous areas shall generally be suitable for gas group IIB and temp classification T3 as applicable to the selected type of explosion protection. In case of hydrogen or hydrocarbon mixtures having more than 30% hydrogen, the gas group to be considered shall be IIC.

As additional safety features, the following requirements for electrical equipment shall be followed:

1. All electric motors for agitators/mixers and metering pumps handling flammable material shall be flameproof type (Ex-de) irrespective of the area being classified as zone-2 or zone-1.
2. All electric motors for vertical sump pumps handling flammable material shall be flameproof type (Exde).
3. Irrespective of the area classification (whether zone-1 or zone-2), all lighting fixtures within the storage areas shall be flameproof type (Ex-d).
4. Irrespective of the area classification (whether zone-1 or zone-2), all motors and lighting fittings within the pump house near the offsite tank farm and within the loading/unloading gantries shall be of flameproof type (Ex-d).
5. All emergency/critical lighting fixtures and associated junction boxes in hazardous areas (whether zone-1 and zone-2) shall be flameproof type (Ex-d).
6. Even though fired heaters in process units are not considered for area classification, all electrical equipments associated with fired heaters in process units shall as a minimum be suitable for installation in Zone-2 area.
7. Where air conditioning system is designed considering ammonia as refrigerant, the room housing air conditioning equipment shall be adequately ventilated to classify it as safe area. For additional safety the following shall be considered:
   - 100% standby system for ventilation
   - Location of MCC/local panels in adjacent separate room.
   - Instrumentation to be flameproof type or hermetically sealed.
   - AC plant room motors with type‘e’ protection.
   - Lighting in AC plant room suitable for zone-2 area.
8. Building such as Compressor sheds inside the process area shall be designed to allow adequate ventilation to allow area classification as Zone-2. Lighting equipment, EOT
crane etc. in the shed shall be flameproof type (Ex-d). All other electrical equipment shall be suitable for Zone-1 or Zone-2 area depending on extent of hazard.
9. All HV motors for hazardous area Zone-1 shall preferably be flameproof type (Ex-de). Pressurised motors may be provided in exceptional cases.
10. Ex-n motors without pre-start ventilation as permitted by Indian Standard unless any other type is specified by Process Licensor, shall be provided, except for the following cases as listed below:
   - HV motors for Centrifugal compressors (As Ex-n motors are not recommended for use for such applications as per IS/IEC-60079-15 and therefore Ex-de or Ex-p motors shall be provided for these applications)
   - For motors in Zone-2 areas having frequent start/stop requirements e.g. EOT cranes/Elevators, MOV actuators etc., Ex-de motors shall be used.
11. For Zone-2 areas, motors with ratings above 100kW having average starting frequency of more than one per week, Ex-n motors with pre-start ventilation provision or Ex-de or Ex-p motors shall be used.
12. Ex-p motors shall be used for large rating motors where Ex-de or Ex-n motors are not available.

4.0 SYSTEM DETAILS AND UTILIZATION VOLTAGES

4.1 The various voltage levels for in plant power distribution shall be as follows:

<table>
<thead>
<tr>
<th>A. Normal Power</th>
<th>11KV ± 5%, 50Hz ± 3%, 3Ph, 3 W</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Emergency Power</td>
<td>Voltage Variation ± 5%, 50Hz ± 3%, 3Ph, 3 W (DGs shall be in LSTK Contractor’s scope).</td>
</tr>
<tr>
<td>C. Distribution Equipment</td>
<td>a) 11KV ± 10%, 50 Hz ± 5%, 3 Ph, 3 W with resistance earthed neutral</td>
</tr>
<tr>
<td></td>
<td>b) 3.3KV ± 10%, 50 Hz ± 5%, 3 Ph, 3 W with resistance earthed neutral</td>
</tr>
<tr>
<td></td>
<td>c) 415V±10%, 3 Ph, 4 W/240V ± 10%, 1 Ph, 2W, 50 Hz ± 5% solidly grounded neutral.</td>
</tr>
<tr>
<td>Combined variation in voltage &amp; frequency</td>
<td>± 10%</td>
</tr>
</tbody>
</table>

Control Supply for:
- 415V motors
  - Switch Gear Breaker controlled feeders:
    a. Closing, tripping & spring charging motor
    b. Auxiliary power

- Switch Gear Breaker controlled feeders:
  a. Closing, tripping & spring charging motor
  b. Auxiliary power

- Instrumentation and Automation, DCS & Auxiliaries

<table>
<thead>
<tr>
<th>Voltage Ratings</th>
<th>AC 115 V ± 10%, 50 Hz ± 3% 1Ph, 2W – Instrumentation UPS located at Control Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Supply for:</td>
<td>AC 240V ± 10%, 50 Hz ± 5%, 1Ph (For contactor controlled motors) – Electrical UPS located in Substation.</td>
</tr>
<tr>
<td>DC 110V ± 5% (For breaker controlled motors) – Battery Charger</td>
<td></td>
</tr>
<tr>
<td>DC 110V ± 5%, 2 W - Battery Charger</td>
<td></td>
</tr>
<tr>
<td>AC 240V ± 10%, 50 Hz ± 5%, 1Ph, 2W</td>
<td></td>
</tr>
<tr>
<td>Instrumentation and Automation, DCS &amp; Auxiliaries</td>
<td></td>
</tr>
<tr>
<td>Voltage Ratings</td>
<td>AC 115 V ± 10%, 50 Hz ± 3% 1Ph, 2W – Instrumentation UPS located at Control Room</td>
</tr>
</tbody>
</table>
4.2 Electrical System Studies

4.2.1 Contractor shall carry out following minimum Electrical System Studies using latest software preferably ETAP and the result of the same shall be furnished.

- Load Flow Studies
- Short Circuit Studies
- Motor Starting Studies
- Relay Co-ordination and Relay settings.

Electrical Equipment shall be designed as per worst operating conditions.

4.2.2 The actual fault levels shall be arrived at on the basis of incoming power source, transformers, contribution of motors, etc. and shall be indicated in the Bid.

All switch boards of the same voltage shall be rated for identical fault level. Minimum fault level to be considered for design and selection of equipment shall be as follows:

- 11 kV Switchgear – 40KA for 3 Seconds.
- 3.3 kV Switchgear – 26.24KA for 3 Seconds.
- The fault level for 415V switchboards shall be 50KA for 1 sec.

Impedance of transformers shall be selected suitably (tap position at principal) without comprising voltage drop at receiving end.

11KV/0.433KV or 3.3KV/0.433KV Transformer rating shall not be more than 2000kVA.

Fault level of DC System shall be decided by the LSTK Contractor after substantiating the same by calculation.

4.3 System Earthing

The neutral of 11 KV and 3.3 KV systems shall be non-effectively earthed through resistance. The earth fault current of 11 KV and 3.3 KV shall be limited to full load current of the transformer or 400 A, whichever is less.

The neutral of 415V supply system shall be solidly earthed.

The DC system shall have positive pole earthed through high impedance. Prospective touch voltage earthing shall comply with the requirements of relevant Indian/IEC standards.

5.0 POWER SUPPLY AND DISTRIBUTION.

5.1 Power supply from 11 KV switch board in Main Receiving Substation to substation of Plant

5.1.1 2 Nos. 11 kV Feeders shall be made available in 11 kV Switchboard at Main Receiving Substation. Tapping of power supply from 11 kV Switchboard at Main Receiving Substation (including supply of all required material), structural supports for cable tray, cable trays,
cables, cable termination etc. shall be in LSTK Contractor’s scope. Further distribution to equipment at 11 KV, 3.3 KV, 415/240 V, 115 V (UPS) AC, 240 V (UPS) AC, 110 V DC etc. through proper type and size of cables, their supply, erection, testing and commissioning etc. shall be in LSTK Contractor’s scope.

LSTK Contractor shall consider 11kV/3.45kV, 11kV/0.433kV or 3.3 kV/0.433kV transformers for downstream distribution. The supply system shall be designed for maximum power requirement of the plant. Double radial system of power supply, each suitable for 125% of full load shall be followed for entire plants.

LSTK Contractor shall indicate details of power requirement and the Rating of 11KV Feeders at Main Receiving Substation in the Bid.

5.1.2 In the event of failure of normal power in the plants, the plants shall be brought to safe shut down condition through Emergency power. Emergency power shall cater to the load of emergency lighting, UPS system, battery charger, motorized valves, Fire alarm system, PA & Paging system in addition to the process loads for safe shutdown of the Plant and wherever required as per detail design.

The emergency power shall be arranged through suitably 125% rated DG Set. Emergency Power shall be tapped from DG Distribution Board through cables (Supply, installation, testing, commissioning shall be in LSTK Contractor’s scope). Further distribution to all emergency equipments etc. including transformers shall be in LSTK Contractor’s scope.

The capacity of DG Sets shall be finalized by the LSTK contractor to meet the emergency power requirement of Plant alongwith its Associated Utilities and internal consumption of the DG Sets keeping a margin of 25% over the actual requirement. DG Sets & Diesel tanks shall be located at centralized place at a minimum safe distance from substations as per relevant IS/IEC of hazardous area classification. Further distribution to all emergency equipments through proper type and size of cables, their supply, erection, testing & commissioning etc. shall also be in LSTK Contractor’s scope.

DG Sets shall be suitable for starting of the largest emergency motor.

DG Sets shall be of continuous duty.

DG Sets shall be suitable for Black start.

In the event of plant black out and/or sustained under voltage on Emergency Switchboard(s), Diesel Generator set shall be started automatically.

After restoration of normal power, provision of automatic stopping of DG Sets after synchronization (Load transfer without Break) with time delay shall be provided as well as bypassing of same shall also be provided. In case of bypass, manual control of DG sets shall be from DG Control Room. Restoration of normal power, stopping of DG shall be done from the DG Control Room. DG room shall have adequate space to house Emergency Power Distribution Switchboard. The DG sets shall have provision of starting and stopping and monitoring of all parameters through LMS.

Further distribution to all emergency equipments of Plant at required voltage shall also be in LSTK Contractor's scope.

Normally DG sets will not run in parallel with Main (Grid) power. But for Load testing and load sharing requirement, DG sets should have the facility and required Control /Protection to Run the DG sets on with parallel to the Grid for continuous basis.

DG Set shall be of continuous duty. The auxiliary load shall be minimised.

DG Set shall be located inside building. The building shall have RCC Roof.

5.1.3 The electrical system layout and interconnections (power as well as control) shall be such that the problem in electrical system of one plant should not affect the electrical system of other plant and vice versa.
5.1.4 The insulation system of cable, 11 KV & 3.3 KV equipments shall be based on unearthed system only.

5.1.5 Each incoming feeder shall be sized for 125% load of the switch board. The outgoing feeders shall be sized for the nominal load. Breaker rating of all the outgoing feeders of 11KV switchboards & & 3.3 KV switchboards shall be same considering provision of interchangeability.

5.1.6 Primary connections of transformers shall be provided with cables of suitable size and secondary connections shall be through cables/bus duct.

5.1.7 The entry of cables in the switchboards shall be from bottom only.

5.1.8 All switchboards shall be provided with minimum two incoming feeders and one bus tie having auto/manual changeover facility.

5.1.9 It shall be possible to have momentary paralleling of power sources at 11 KV, 3.3 KV switchboards and 415V PMCC /PCC/MCC and trip the desired circuit breakers.

5.1.10 The normal operation of the 11 kV, 3.3 kV Switchgears, Power & Motor Control Centre (PMCC) and Motor Control Centre (MCC) shall be as under:

i. Bus-coupler shall be provided between all the sources. Incomer and Bus-coupler breaker rating shall be same for all the switchboards. Each incoming feeder shall independently feed the loads on respective buses with full rated bus tie breaker open and the load on each bus balanced. In order to ensure maximum degree of reliability and continuity, automatic transfer from one incoming feeder to other shall be possible through auto/manual closing of bus tie breaker in case of sustained loss of power on any bus section.

ii. The bus tie breaker shall be provided with auto/manual selection. The bus tie breaker shall be independent in manual mode. In auto selection mode, the bus tie breaker is electrically interlocked with incoming circuit breakers, so that it cannot be closed unless one of the incoming breakers is open.

iii. When one of the incoming feeder trips, the bus tie breaker is closed automatically based on the philosophy described and the total load is transferred to other healthy incoming feeder which is capable of carrying the entire load. Sufficient switchgear capacity is to be provided. Time for changeover is suitably selected based on downstream system requirement of reacceleration of motors etc.

iv. Auto Change Over scheme shall be provided for incomer feeders and bus coupler feeder of 11kV switchboard, 3.3kV Switchboards and 415V Switchboards. Under normal operating conditions, incomer-1 and incomer-2 breakers shall be closed and bus coupler breaker shall remain open with ‘Local-Remote-Off’ switch in ‘Remote’ position. The bus coupler breaker shall close automatically under the following conditions being fulfilled:

- Either of the incoming breaker trips due to under voltage (70% or below).
- Voltage on the healthy bus is more than 80% for the set period.
- Residual voltage on the bus with no power supply comes down to 30% or below.

Required nos. of bus PT, line PT and under voltage relays shall be provided to achieve the desired automatic changeover.

v. Auto transfer shall take place only on sustained loss of power on either of bus sections. Auto transfer shall be blocked in case of fault on either of bus sections or no power on both incomers.

vi. Paralleling of two incoming feeders is not foreseen. However, facility for momentary paralleling shall be provided for intentional changeover without interruption of supply with synchro check relay in Bus Coupler panel. There shall also be provision of selective tripping of one feeder out of three feeders with a Delay (two incoming feeders and one Bus Coupler).

5.1.11 HV emergency board shall also have 2 normal and 1 emergency incomer. EPMCC shall have 2 Nos. Normal Power Incomers & 1 No. Emergency Power Incomer feeding critical
load of plant whereas PMCC & MCC shall have 2 Nos. Normal Power Incomers feeding non-
critical loads. DC Battery Charger, UPS System etc. shall be fed from EPMCC. PMCC shall
fed breaker controlled feeders and various power feeders whereas MCC shall fed contactor
controlled load and various power feeders. PMCC and MCC shall be separate.

5.1.12 Auxiliary Services Power Board (ASPB) having essential bus (to be fed from Emergency Bus
of EPMCC) and nonessential bus (to be fed from Normal Bus of EPMCC) shall be provided
in the plant for supplying power to welding switch sockets, lighting load, EOT crane and
other auxiliary loads.

5.1.13 Separate MCCs be provided for air conditioning and ventilation systems.

5.1.14 For the use of the Owner during plant shut down period, each area shall be provided with
indoor type feeder pillar, which shall be located in a separate room other than substation
building and away from hazardous area. The feeder pillar shall be fed from the 415 V
switchboards (PMCC) of the nearby substation. Each feeder pillar shall comprise of 1 No.
630 A 4 P MCCB incomer, 2 Nos. of 250 A TPN MCCB outgoing feeders, 2 Nos. 125 A TPN
MCCB outgoing feeders and 4 Nos. 63 A TPN MCCB outgoing feeders. Other construction
details shall be as per specification of sheet steel distribution board (PC150-TS-0808).

Location of feeder pillar shall be decided during detailed engineering.

5.2 **Instrumentation Power**

5.2.1 The power supply for instrument shall be 115V, 1Ph from UPS System.

5.2.2 Provision for 240V, 1 Ph power for lighting of instrument panels shall be provided from
LSDB.

5.2.3 All instrument panels shall have two UPS incomer supply (one from different bus of UPS
DBs) to avoid any type of power obstruction in case of failure of one supply.

5.2.4 Separate 240VAC UPS System shall be provided to feed MCC control supply, Control Room
(to meet 250 lux in case of UPS Supply only) & Substation lights (30% of total light) , LMS
Equipment, Fire Detection & Alarm System etc. This UPS System along with associated
Battery (Ni-Cd) and UPS distribution Board shall be located at Substation.

5.3 **Lighting Distribution**

5.3.1 In each substation a Main Lighting Distribution Board (MLDB) shall be in provided. MLDBs
shall have two incomers from PMCC through 415/433 V Lighting Transformers. Two Incomer
of MLDB to be fed from two separate Bus section of PMCC. However, in other areas the
Lighting Distribution Boards shall receive power from MLDB. One third lighting load shall be
connected to the emergency power (DG Source) to provide emergency light during failure of
normal power. Both the MLDB Incomers and Incomers of other LSDB (excluding field
mounted LSDBs) shall have Metering facility with Digital communicable Multi-function
Meters.

Both the lighting transformers feeding MLDB and their respective circuit breakers shall have
same rating. Both the lighting transformers shall be designed for 100% load of MLDB.

33 % of total light of plant excluding Substation & Control Room shall be fed from

10% of light or required Number of lights for safe evacuation at strategic locations, whichever
is higher, shall be used as panic light (110V DC), in case of complete shutdown for the
plant area excluding Substation & Control Room.

5.3.2 The both normal and emergency section of Main Lighting Distribution Board shall have
separate Sections of busbars for indoor and outdoor lighting. Indoor / Outdoor bus Sections
shall be connected by means of suitably rated contactor operated through photo-cells /
digital clock timer.
5.3.3 Manual by-pass circuit for outdoor lighting shall be wired up to a switch located in Electrical control room / shift office, so that outdoor lighting can be switched ON or OFF manually to bypass the automatic switching.

5.3.4 All outdoor lighting fixtures and outside lighting of Sub-Stations, Offices, Control Rooms etc., shall receive power from outdoor lighting bus.

5.3.5 All Lighting fixtures / electrical equipment in Analyzer room shall be flame proof type.

5.3.6 Main Lighting distribution board shall feed Lighting Sub Distribution board having 63A 4 Pole MCB and ELCB as incomer, 16Amp DP MCB and ELCB as outgoing. The outgoing ELCB shall have rating of 300/100 mA. Six, Nine or Twelve way Lighting Sub Distribution board shall be used having 30% as spare outgoing MCB feeder.

5.3.7 Welding outlets shall be fed from ASPB having 3 phase supply for welding connection. All welding outlets shall be provided with CBCT ELCB of 100 mA.

5.4 DC Power

5.4.1 110 V DC system shall be provided for control of circuit breaker feeders and panic lighting. It shall be obtained from Ni-Cd batteries. Separate dedicated Battery, Battery Charger and DC Distribution Board shall be provided in each substation.

5.4.2 The battery shall be provided with SCR controlled automatic rectifier-cum battery chargers and shall consist of Main Float cum Load charger, Standby Float cum Load charger and Boost Charger and 2 Nos. Battery Bank each of 60% capacity (of 5 hours backup at 100% capacity) with isolation facility for ease of operation & maintenance.

5.4.3 Each rectifier-cum-battery charger shall have independent power supply to be fed from the emergency source.

5.4.4 Each Substation requiring 110V DC shall have 2 sources with auto changeover facility in case of failure of 1 source.

5.4.5 DC Battery Charger, AC UPS and HVAC for control room shall be fed from emergency switchboard.

5.4.6 Battery end cell voltage shall 1.1V. Aging factor shall considered 125% and spare capacity shall have 120%.

5.4.7 For Temperature derating factor shall be based upon Minimum Ambient Temperature i.e. 5°C.

5.4.8 Battery Charger shall have at least 20% extra capacity for future load requirement. Battery Charger shall have 110 V DC system.

5.4.9 Separate Rectifier-Cum-Battery Charger with DC Distribution Board and Battery Bank shall be provided for each Substation.

5.4.10 The battery and charger combinations shall be such as to ensure continuity of D.C. supply at load terminals without even momentary interruption.

5.4.11 AC Ammeter and AC Voltmeter on Charger Input; DC Ammeter, DC Voltmeter for charger output/ battery voltage and on demand type Battery Charge / Discharge Ammeter shall be provided.

5.4.12 For all other specifications of Battery Charger, refer PC150-TS-0813.

5.4.13 For all other specifications of Battery Bank, refer PC150-TS-0814.

6.0 SUB-STATION

6.1 Elevated with trays in cable cellar : Yes

6.2 Air-conditioned room for operator : Yes

6.3 Roof slab for
6.12 The Sub-Stations shall be located near the load centres but away from hazardous areas as per IS/IEC. Actual size of substations shall be based on the final dimensions of substation equipments. Each Substation shall include Maintenance room, Engineer Room, Shift Office (Staff Room), Gents toilet (both Indian and western WC), Ladies toilet (both Indian and western WC) etc.

6.13 The sub-station building shall have double storey construction. The ground floor shall have cable gallery and first floor shall have all switchboards, control panels etc. The switch room shall have Kota stone flooring. False ceiling shall be provided in VFD room, staff room & Engineers room.

6.14 The cable gallery shall have a minimum clear height of 2.2 M (i.e. lowest cable tray should run at a height of 2.2 mtr. from finished floor level of cable cellar) and shall be closed on all 4 sides with two entries, preferably on opposite sides. It shall house all cable trays and their supports

6.15 Transformer floor shall be at least 300 mm above the finished floor level of cable cellar room.

6.16 In addition to the entry to substation for operating personnel, a separate entry of minimum 3.5M (H) X 3M(W) with rolling shutter shall be provided for all equipment entry. The rolling shutters should be manually operated with gear box. The Sub-station shall also have an emergency door opening outwards.

6.17 Sub-station wall adjacent to the transformer bays and walls separating transformers shall be 355 mm thick (inclusive of plastering) in case of brick construction or 240 mm thick in case of RCC construction upto roof slab. RCC roof slab shall be provided for Transformer, Series Reactor, capacitor and Cathodic Protection Equipment. The gate of Transformers shall be designed to prohibit bird entry.

6.18 Adequate number of Portable Fire Extinguishers of Dry Chemical Powder and Carbon dioxide shall be provided in suitable location in Substation, Transformer bays, Control room building and DG Building etc. These extinguishers will be used during the early phase of fire to prevent its spread and costly damage.

All extinguishers shall be supplied with initial charge and accessories as required.

Portable type extinguishers shall be provided with suitable clamps for mounting on walls or columns.

All extinguishers shall be painted with durable enamel paint of fire red colour conforming to relevant Indian Standards.

Dry chemical powder type extinguisher shall conform to IS: 2171.

Carbon Dioxide type extinguisher shall conform to IS: 2878.

6.19 Sub-station building shall be without any columns within the switchgear room to ensure optimum space utilization.

6.20 The layout of equipment shall be such that it shall have adequate space for installation, operation, maintenance and future expansion. The clearance of equipment from the
walls/other equipment shall be adequate to ensure safety of working personnel. Generally the following norms shall be maintained for 33/11 KV/3.3 KV/415 V Switchboards:

a) The clear space of 2.5 M at rear side of 33/11kV/3.3 kV Switchboard.

b) A clear space of 1.5M behind the double front switchboards and 1M for single front.

c) A clear space of 3.0M between the two boards facing each other.

d) A clear space of 2.5M on either side at entrance/exit.

e) A clear space of 2.0M between two boards in same line after future panel space of switchboard.

f) A clear space of 1M in switch room from top of equipment.

6.21 The substation Switchgear Room, UPS & Battery Charger room, LMS room, Maintenance room, Engineer Room, and Shift Office shall be fully air conditioned through HVAC with (n+1) system, however all the equipment shall be suitable for operation under specified ambient condition even on failure of air conditioning system. The substation shall have HVAC system so that the temperature inside the substation is maintained at 25 Deg.C in all conditions. Provision for remote alarm on failure of air conditioning system shall be provided. Indication of substation and control room temperature shall be provided. Heat load to be calculated on the basis of heat generation in the substation during peak summer period. Fire damper to be provided in the ventilation duct of the HVAC. There should be a separate room for installation of the HVAC Units located at ground floor.

6.22 Epoxy flooring shall be done to reduce the heat load and improve the aesthetic look.

6.23 The battery room shall form a part of the sub-station. Battery room shall be provided with minimum two flameproof exhaust fans and louvered opening in opposite wall/door. A sink with water tap shall be provided with water connection. Eye wash shower shall also be provided. Floor of the battery room and walls up to 2 M height shall have acid/alkali resistant protective epoxy coating. Light fittings, exhaust fan, on/off switches etc. in this room shall be chemical resistant type and flame proof type.

6.24 Location of battery charger shall be nearer to battery room.

6.25 To the extent possible Bus duct shall be in straight position. Bending of bus duct shall be avoided.

6.26 Staircases (with SS Handrail) and other rooms shall be paved with Kota stone.

6.27 Fixed type glass ventilators on all sides shall be provided near the ceiling height for natural lighting.

6.28 Arrangement shall be provided for lifting heavy equipment to be brought into the sub-station.

6.29 Sufficient nos. of entrances (min. 2) shall be provided for each floor.

a. All doors of sub-station shall be air-tight fire proof steel doors except doors of control rooms/ PLC rooms which may have anodised aluminium frame with toughened glass panel. All doors shall open towards exit.

b. Windows shall have anodised aluminium frame and provided with toughened glass.

c. In case height is more than 10 meters, elevators (of capacity for 10 persons) shall be provided. Elevator shall be suitable for the area of installation.

d. 1000 mm wide insulated rubber mat of appropriate voltage grade shall be provided in front as well as rear of each panel.

6.30 The Sub-stations shall also have an emergency door opening outwards.

6.31 The sub-station shall house all the electrical power, control and monitoring equipment except those required for operation in the field. The equipment shall broadly include the following:

- Transformers located in separate Bay/Room.
- High Voltage Switch Boards
- Power Control Centres
- Power & Motor control centres
- Emergency Power & Motor control centres
- Motor Control Centres
- Auxiliary Service Panel Boards
- Lighting Transformer (Indoor / Outdoor as per requirement)
- Main Light Distribution Board
- Lighting Distribution Boards
- Lighting Sub-Distribution Boards
- Battery Sets
- Rectifier-Cum-Battery Charger
- DC Distribution Boards
- Rectifier-inverter Sets
- UPS System alongwith UPS distribution board.
- Neutral Earthling Resistors (Indoor / Outdoor as per requirement)
- Input / Output Panels
- VFD System
- Any other equipment required

6.32 All static devices such as Rectifier-Cum-Battery Chargers, Variable Speed Drive Panels, Soft Starter etc., shall be housed in a separate room. Heat load for panel to be taken by panel manufacturer.

6.33 Separation walls between transformers in all substations and safe inter transformer distances for switchyard transformers shall be provided.

6.34 Transformers shall be located in bays adjacent to the sub-station building. All bays shall have oil drained floor, surfaced with gravel or other suitable material.

6.35 In order to prevent leaking oil from reaching and polluting the water bearing stratum, transformers shall have the following provisions, depending on the oil capacity of the transformer.

    Oil Capacity up to 2,000 litres:
    Transformers installed adjacent to sub-station shall be provided with oil soak pit with a layer of pebbles of about 40 mm granulation.

    Oil Capacity exceeding 2,000 litres:
    Transformers installed adjacent to sub-station shall be provided with oil collection pit and sump pit as per Drg. No. PC150-PDS:E 114 for draining away of any oil, which may escape or leak from the tanks, to a waste oil tank.

6.36 A clear space of at least 1.5 meters shall be maintained all around the transformers after installation of Nitrogen Fire Protection & Extinguishing System etc. Nitrogen Fire Protection & Extinguishing System complete with piping as required shall be separate for each transformer.

6.37 Separate common oil pits are required for Transformers.

    The volume of common oil pit will be 125% of the volume of oil of the transformer, which contains the largest volume of oil in transformers.

    The oil pit will be closed type of water-proof concrete construction.

    The oil pit will be connected to individual pit under each transformer and drain line of each transformer will be at least 150 mm dia pipe with a minimum slope of 1:96 as per TAC Regulation.

    Transformer fire/drainage of oil will be considered for only one transformer at a time.
Level of pit will be so selected that there would not be accumulation of oil/water/oil-water mixture in the pit under each transformer.

Pit shall be provided with 2 x 100% sump pump for common oil sump. 1 No. Portable sump pump shall also be provided.

Oil Pit under Transformer and its Cooler Bank: Gravel filled open oil pit will be provided under each transformer and its cooler bank. The pit shall be such that it can take oil/water surge of 20% of the volume of the transformer oil. Level of pit shall be such that there will not be accumulation of oil/water in the pit. The gravel size will be 60 mm. Each pit will be connected to the drain line leading to new common oil pit.

6.38 In all substations/MCC rooms, space for future extension of switchboards shall be provided. Two panel extension space on each side (for each bus section) shall be provided for all HV Switchboards, PCCs. One panel extension space on each side (for each bus section) or two panel extension space on one side (in exceptional cases) shall be provided for all PMCCs, MCCs and ASPBs.

In addition, space for future extension of the substation/MCC room building shall be considered. Substations shall have provision for future expansion Minimum 5 Mtrs space for future horizontal expansion.

6.39 Fire protection for substations shall be provided to comply with requirements of relevant BIS (Bureau of Indian Standards) and other Indian/International standards, as applicable. In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA/NFPA or equivalent agency shall be applicable.

In case of contradiction/conflict, most stringent specification shall be followed.

Substations shall be provided with smoke detectors and fire alarm system as specified elsewhere in the ITB and as per relevant Indian Standard.

6.40 Fire barriers shall be provided at cable/bus-duct entry/exit point. Cable shall have fire protection paint for 1 m length at building entry points for above ground cables.

7.0 PROTECTION & METERING

7.1 Selection and co-ordination of protection and metering system shall be such as to ensure:

- Selective, sensitive and reliable protection of equipment against damage due to internal or external faults or atmospheric discharge.
- Isolation of fault in the shortest possible time.
- Simplicity of the scheme with maximum protection.
- Uninterrupted operation of healthy system.
- Personnel & plant safety.

7.2 Protective relays shall be of latest version, numerical / communicable type with non-volatile memory, comprehensive unit providing protection, metering, control and communicable with communication port for interlinking with online energy/Load Management System. 100% redundancy shall be provided for communication i.e. the Relay should have minimum 2 Nos. IEC-61850 communication port in addition to Front Port. Numerical Relay shall have communication on IEC-61850 protocol in redundant mode and meters shall have communication on MODBUS protocol.

7.3 Numerical relay shall indicate MWH, MVAR, MVA, V, A, Hz, PF. It shall have future provision for connecting with substation HMI. Separate multifunction meter with communication (for centralized energy monitoring) shall be used and shall not be part of protective device.

7.4 Relays shall support features like remote relay parameterization, disturbance recorder etc. It shall be possible to set/operate the relay from the front facia. Lock out relay shall be conventional type with hand reset facility.

7.5 Contractor shall supply licensed (lifetime) software along with required communication cables for Parameterization and viewing of disturbances, events, etc. through Laptop for all
Make and models of Numerical relays. 1 No. Laptop complete (8GB RAM, 1 TB hard Disk, latest processor) with all required software shall also be provided.

7.6 Special protection if required for any feeder such as differential, restricted earth fault, directional distance power relays etc. shall also be through numerical relay having serial port for monitoring.

7.7 In general all protection shall be through microprocessor based numerical relay. However high speed tripping relay shall be separate.

7.8 All Auto-changeover logic to be built in Numerical Relay. Numerical Relays shall have sufficient I/O to cater the same and there should be minimum 10 % spare I/O for future use. External I/O Card/ Module are not acceptable.

7.9 All Process Stop and other important Parameters shall be routed through Numerical relays for recording and Time-stamping. Hardware Annunciator is not required. Common Audio Visual Alarm for each Bus section of Switchboard shall be provided through Numerical relays.

7.10 Bare minimum protection for power distribution system shall be as indicated below. However, LSTK contractor shall provide any other necessary protection required for complete protection of system:

Protection devices for power distribution system shall be as indicated below (Figure inside bracket refers to note below) (YES – Applicable)

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>1.</td>
<td>IDMTL Over-Current Relay</td>
<td>51</td>
<td>YES</td>
<td>YES</td>
<td>------</td>
<td>YES</td>
<td>YES</td>
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<td>2.</td>
<td>IDMTL Earth-Fault Relay</td>
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<td>3.</td>
<td>Standby / Backup Earth Fault Relay (earthed neutral)</td>
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<td>------</td>
<td>------</td>
<td>------</td>
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<td>------</td>
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<tr>
<td>4.</td>
<td>Motor Protection Relay with (50, 50N, 46, 49, 50L/R, 95)</td>
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<td>------</td>
<td>------</td>
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<td>YES</td>
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<td>5.</td>
<td>Instantaneous Restricted Earth Fault Relay (Earthed side)</td>
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<td>------</td>
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<td>------</td>
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<td>Instantaneous Overcurrent Relay</td>
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<td>YES</td>
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<td>7.</td>
<td>Instantaneous Earth Fault Relay</td>
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<td>------</td>
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<td>8.</td>
<td>Differential Protection Relay</td>
<td>87</td>
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<td>YES (7)</td>
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<td>YES (8)</td>
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<td>High speed tripping relay</td>
<td>86</td>
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<td>Trip Circuit Supervision Relay</td>
<td>95</td>
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<td>11.</td>
<td>Transformer Auxiliary Relay</td>
<td>63</td>
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<tr>
<td>12.</td>
<td>Under Voltage Relay with timer</td>
<td>27 / 2</td>
<td>------</td>
<td>------</td>
<td>YES</td>
<td>------</td>
<td>YES</td>
<td>(9)</td>
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<td>13.</td>
<td>Check Synchronisation Relay</td>
<td>25</td>
<td>------</td>
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<td>------</td>
<td>------</td>
<td>YES</td>
<td>(10)</td>
<td>YES</td>
</tr>
</tbody>
</table>
Notes for Relay Protection Philosophy

1. All the numerical relays shall be of communicable type and connected to LMS on IEC 61850 (Ethernet based) communication protocol with time stamping and time synchronization.

2. In case of HV switchboards with continuous parallel operation of incomers, following additional relays shall be provided:
   a. One set of 87B (Bus differential) and 95 B (Bus wire supervision) for each bus section.
   b. 32 (Directional IDMTL over current and earth fault) relays for the incomers.

3. In case of grid power supply EHV incomer following additional relays shall also be provided:
   a. Relay 21 for distance protection, Relay 59 for overvoltage protection with timer, Relay 67 for directional over current protection, Relay 67N for directional earth fault protection, Relay 81 for under frequency / df/dt protection and Relay 98 as dead bus charging relay.
   b. Minimum protection relays for EHV Transformer shall be 50, 50N, 51, 51G, 51N, 63TX, 64R, 86, 87T, 87F & 95.

4. Instantaneous earth fault (50N) shall be provided only for transformer with delta primary.
5. Directional IDMTL earth fault (67N) shall be provided for transformer with star primary.
6. For transformers rated 5 MVA and above.
7. For motors rated 1500 kW and above, excluding VFD fed motors.
8. For critical/long feeders and plant feeders connected to main power generation and distribution bus. A plant feeder implies outgoing feeders from one switchboard to another switchboard of same voltage level.
9. Wherever auto-transfer feature is provided.
10. For switchgears where continuous or momentary paralleling of incomers is envisaged, check synchronizing relay shall be provided.
11. 51G and 64R relays for input transformer of VFD system shall be decided by VFD Manufacturer.
12. The bus tie feeders in HV switchboards shall be provided with 51, 51N, 86 and 95 relays.
13. HV capacitor bank feeders shall be provided with 51, 51N, 59 (over voltage), 60 (Neutral displacement), 86 and 95 relays.
14. The following feeders shall be provided with timers for delayed tripping on bus under voltage while the under voltage relay shall be common for the bus
   a. HV and MV capacitor feeders.
   b. HV and MV breaker controlled motor feeders.
   c. Contactor controlled motor feeders with DC control supply.
   Numerical relays where ever provided for motor and capacitor feeders shall use in built under voltage relay and timer for delayed tripping on bus under voltage.
15. One no. DC supply supervision relay (80) shall be provided for each incoming DC supply to the switchboard.
16. One set of bus differential relays (87B) and bus wire supervision relay (95 B) for each bus section shall be provided for HV switchboards connected directly to generation busses.
17. In case of numerical relays, all relays shall be comprehensive units including all protection, metering and control.
18. Under voltage and over voltage function along with associated timer shall be part of the numerical relays.
19. Auto changeover scheme control & logic between Incomers and bus coupler shall be built in the numerical relay.
20. Tripping relays (86) shall be separate relay. There shall be two nos. high speed tripping relay for motor feeder. One for electrical fault and one for process fault. Electrical fault relay shall be hand reset type and process fault relay shall be self reset.
22. Stand by earth fault relay 51G shall be provided in the incomer of switchboard fed from transformers where transformer & switchboard both are located remotely from HV substation as well as in same HV substation.
23. For transformers located remotely away from HV Substation, a local power isolating device in the form of breaker panel without any protection relay shall be provided before transformer. A local emergency stop push button (Lockable) shall also be provided in transformer bay for tripping remote breaker.
24. Restricted earth fault relay 64R shall be provided for transformer rating >= 1 MVA in the incomer of switchboard fed from transformers having secondary winding star connected. This shall trip the HV side breaker.
25. 3.3kV DG set shall be provided with protection but not limited to 51V,51G,40,46,86,95,80,64R etc. for generator rated above 500KVA and Generator rated less than 500KVA shall have 51V,51G,40,46,86,95,80 unless otherwise agreed with the owner.
26. Relay 87 and 64R shall be separate numerical relay. Hence shall not be part of main comprehensive numerical relay. CT for 87 and 64R can be clubbed, as two core of single CT.
27. Accuracy class of the current transformers shall be
   - Class PS for differential and special requirements.
   - Class 1.0 / 0.2 S for metering purpose.
   - Class 5P20 for protection purpose
   All the CTs shall have rated burden of minimum 15 VA and secondary rated current of 1 A.
28. Accuracy class of the potential / voltage transformers shall be
   - Class 5P for protection purpose.
   - Class 1.0 for metering purpose.
   All the PTs shall have secondary voltage 110 V or 110 V / sqrt.3 and rated burden of minimum 50 VA per phase for both metering and protection core.
29. All the incoming, outgoing and tie breaker feeders of any HV & MV Switchboard shall be provided with numerical relays only with communication facility as protection devices. Releases shall not be acceptable in any case. The relays for outdoor 66 kV EHV switchyard shall also be of numerical type with communication facility.
30. Numerical relays in all HV motor feeders shall be suitable for RTD / BTD inputs.
31. Each bus section shall be provided with separate under voltage relays.
32. Multifunction meter shall be provided to keep a record of power consumption and supervision of all concerned parameters like current, voltage, power, frequency, power factor etc. as specified. All the metering instruments shall be flush mounted.
33. Separate Communicable Digital Multifunctional meters shall be provided in all feeders with Numerical Relays for communication with LMS system.
34. Motors shall also be provided with Unbalanced (-Ve) Sequence Protection Relay (46), as required.
35. Numerical under voltage relays (27) with time delay relay including VT fuse failure relay shall be provided for Bus VTs.
36. All Motor feeders of PMCC & MCC (irrespective of Rating) shall have door mounted communicable (Modbus / Profibus) type Motor Protection relay (MPR) with display.
37. No Meters, transducers or measuring equipments to be installed in the Protection CT circuit.
38. Cable Differential relays for both the end to be supplied by Downstream user contractor i.e. Steam Generation Plant LSTK Contractor. Cable Differential relay will be of Fiber Optic Cable based communication only.
39. All required Alarms and Trips shall be incorporated in the Numerical relays. Sufficient LED shall be available in the Relays.

40. Trip Circuit Supervision relay shall be part of Numerical relay.

7.11 Metering instruments shall be provided to keep record of power consumption and supervision of all concerned parameters like current, voltage, power (Active, Apparent and Reactive), frequency, power factor, Energy (Active & Reactive) etc. All the instruments shall be flush mounted. All meters shall be digital multifunctional meters with communication port for Load management at remote location. Additionally digital type ammeter, voltmeter and Hour Meter shall be provided separately for various feeders as indicated below:

The metering devices in HV and MV switchboards shall be as below:

- Type of metering: Analogue/As part of the Numerical relay

(Figure inside bracket refers to note below) (YES - Applicable)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Feeder type</th>
<th>A</th>
<th>V</th>
<th>Hz</th>
<th>PF</th>
<th>MW</th>
<th>MWH</th>
<th>HM</th>
<th>MVAR</th>
<th>MVAH</th>
<th>MVA</th>
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<tr>
<td>1.</td>
<td>HV Incomer</td>
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<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<td>YES</td>
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<td>HV Bus Tie</td>
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<td>4.</td>
<td>HV Bus PT</td>
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<td>5.</td>
<td>HV Plant Feeder</td>
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<td>6.</td>
<td>HV Motor</td>
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<td>HV Capacitor</td>
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<td>8.</td>
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<td>PMCC Bus Tie</td>
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<td>11.</td>
<td>ACB Outgoing (Non Motor)</td>
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<td>----</td>
<td>YES (kWh)</td>
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<td>12.</td>
<td>MV Motor (&gt;55 KW)</td>
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<td>13.</td>
<td>MCC / ASB Incomer</td>
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<td>MCCB O/G (250A and above)</td>
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<td>MLDB Incomer</td>
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<td>16.</td>
<td>DG Set - HV</td>
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<td>YES</td>
<td>YES (kW)</td>
<td>YES (kWh)</td>
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Notes for Metering:-

1. MVA meter in external power supply incomers shall include maximum demand indication also.

2. Separate analogue type voltmeters with voltmeter selector switch and analogue type ammeters with ammeter selector switch shall be provided for incomers of all switchboards.

3. Ammeter (size 48mm x 48mm) shall be provided in space heater circuit of breaker fed HV & MV motors.

4. Apart from metering which shall be part of the numerical relays, Communicable digital multi-function meters of Accuracy Class 1.0 with suitable Metering CT shall be provided in all the breaker feeders of HV & MV Switchboard i.e. in incomers, bus coupler, outgoing plant feeders, transformer feeders, motor feeders, capacitor bank feeders, etc.

5. Multi function meters with serial communication over RS-485 or fiber optic cable, preferably with IEC protocol shall be provided in all the breaker feeders.
6. Power factor meter shall be provided for synchronous motors in addition to the metering provided for induction motors.

7. For current feedback to DCS and VFD feeders motor current transducers shall be provided and mounted in switchgear panel.

8. CT operated Ammeter for all motor feeders above 5.5 KW, all MOV and LOPs shall be provided at both LCS and feeder end of switchboard.

9. All ammeters for LV motors shall be connected through CT. Only HV motors shall have 3 ammeters or ammeter selector switch or Voltmeter and Voltmeter Selector Switch.

10. Hour run meter shall be provided in all breaker controlled motor feeder.

8.0 CONTROL AND MONITORING

The following provision shall be made for control and monitoring of following electrical equipments.

8.1 Transformers
- TNC switch in primary & secondary side of switchgear.
- Emergency trip from secondary side for tripping primary side of transformer.
- VCB with all required protection to be considered in all the 33kV, 11kV & 3.3kV switchboards.
- Lockable ‘OFF’ push button in transformer room to trip sending end switchgear.
- Ammeter and voltmeter on both primary and secondary side.
- Load break switch with Earthing Switch on transformer primary side (only where primary side circuit breaker is not located in the same sub-station).

8.2 Motors Controlled Through Circuit Breakers
- OFF- ON switch with Ammeter on LCS
- OFF-AUTO/MAN-L/R-ON switch with Ammeter on DCS.
- Ammeter in LCS.
- Current monitoring at DCS/PLC through Dual Channel Current Transducer with Display facility installed at switchgear end, where required from process point of view.
- Emergency trip in switchgear.
- Winding and bearing temperatures of motors shall be available at DCS in control room.
- Process interlock in CCR, where required.
- Indication lamp for ‘ON’, ‘OFF’ and “Ready to Start “ in remote (DCS/PLC etc.)
- Motors controlled through Circuit breakers should also be provided with ammeter, KVAh, KWH and running hour counter. Theses shall be incorporated in Numerical relay Or Multi-function Meter.

8.3 Medium Voltage Motors Controlled Through Contactors
- OFF- ON switch on LCS
- OFF-AUTO/MAN-L/R-ON switch on DCS.
- Current monitoring in DCS, where required from process point of view.
• Emergency Trip in PCC/MCC.
• Process interlock in CCR, where required shall be wired through separate auxiliary relay.
• Indication lamp for ‘ON’, ‘OFF’ and ‘Fault’ in switchgear.
• Indication lamp for ‘ON’, OFF’ and “Ready to Start “ in remote (DCS/PLC etc.)
• Motor space heater & Panel board space heater shall be provided with Ammeter & LED in Switchgear.
• All Motor feeders of PMCC & MCC (irrespective of Rating) shall have door mounted communicable (Modbus / Profibus) type Motor Protection relay (MPR) with Earth fault protection and display.

9.0 EQUIPMENT SPECIFICATION

9.1 General Features

9.1.1 The equipment shall be suitable for tropical climate conditions and corrosive and saline atmosphere.
All electrical equipment accessories and wiring shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.
Fine mesh screen of corrosion resistant material shall be furnish on all ventilating openings to prevent entry of insects.

9.1.2 The equipment to be installed in indoor plant area shall be enclosed in dust, damp and vermin proof enclosure equivalent to IP 54 as per relevant Indian Standards/IEC.

9.1.3 The equipment excluding motors to be installed in outdoor plant area shall have IP 65 enclosure. Motors of Coal Conveyor, Coal Handling Section, Ash Handling Section shall have IP 65 enclosure. Motors of other sections of plant shall have IP 55 enclosure.

9.1.4 4 mm FRP (fire retardant and UV stabilized) canopies shall be provided for all outdoor equipments like motors, starters, LCS, SDBs, sw. sockets etc. PA stations shall have acoustic hood.

9.1.5 The switch boards, to be installed inside the building shall have enclosure IP 4X for HV switchgear, for LV switchgear degree of protection shall be IP 52 up to 1600A rating and IP-4X above 1600A rating. Equipment requiring ventilation opening such as battery charger/UPS etc. located in air conditioning room may have IP 43 enclosure however, opening for the ventilation shall be covered with fine wire mesh.

9.1.6 Creepage distance shall be 31mm/kV (for highest system voltage) for all equipment.

9.1.7 All the electrical equipment shall be provided with rolled aluminium/stainless steel heavy duty double compression type cable glands and crimping lugs for the cable terminations

9.1.8 The outside surface of all equipment shall be painted after suitable pre-treatment by the application of two coats of anti-rust and corrosion resisting epoxy based paints.

9.1.9 All similar equipment (viz. HV Switchboard, LV Switchboard – PCC, PMCC, MCC, EPMCC, ASB, LDB, DCDB, Transformers, Numerical relays, UPS, Battery Chargers, Motors, etc.) supplied against a package should be of single Make only – for ease of O&M and spare management.

9.2 DG Sets

9.2.1 In order to meet the emergency power requirement for critical loads and also for safe shut down; suitably rated DG sets shall be provided. In the event of the failure of normal power; DG set will supply the total emergency power requirement; keeping one DG set of maximum rating as stand by.
9.2.2 DG Sets, Diesel tanks and associated switchgears shall be located at centralized place away and at a minimum safe distance from substations and hazardous areas as per relevant IS/IEC of hazardous area classification. Emergency power from DG Set shall cater to:-

(a) Loads of emergency shut down
(b) Essential loads of the package
(c) Loads of emergency and aviation lighting
(d) UPS Loads
(e) Battery Charger & DCDB Loads
(f) Any other load recommended by the LSTK Contractor for proper and safe operation & control of the facilities under the package.

9.2.3 The DG Sets control shall have PLC/microprocessor based latest state of art technology. Brushless excitation system shall be used in generator.

9.2.4 The starting of engine of DG Sets shall be electric type. System should be capable of minimum 3 starts.

9.2.5 DG Set shall have all its auxiliaries installed andcontrolled from same place. The control of DG Set shall be based on 110 V DC which shall be supplied from the DC panel. Separate DC battery bank with battery charger shall be provided for control supply. Starting Battery and Battery Charger for DG shall be separate. 110 V DC System Battery and Battery Charger may be separate or may be taped-off from Substation DC System. Both Control supply and Starting Battery Charger shall be (1 + 1) configuration.

9.2.6 The auto starting time (i.e. the time between actuation of loss of power in case of failure of main power to the time of loading of total emergency load) shall be in accordance with the requirement of process. The maximum starting and synchronising time of Sets shall be 30 seconds even after 3rd attempt and shall be able to take full load within lower of two i.e process and 45 seconds. The DG power shall be made available within such a period that none of the plant unit is affected due to failure of normal power. LSTK Contractor shall submit during detailed engineering, the calculation for ‘Time to start’ indicating break up of time for voltage build up 100% loading in steps as required.

9.2.7 The auxiliary power supply board to feed the auxiliaries of DG Sets shall have dual power supply, one from the normal power supply source of plant and other from the DG Set itself with the provision of changeover in the incoming supply in auto mode as well as manual mode. The emergency power distribution board shall be kept in a separate room near to engine room of DG Sets. DG Rooms shall be provided for DG Sets. The incomers and larger rated feeders shall be provided with air circuit breakers and Numerical relays. The feeders of smaller ratings shall be provided using MCCBs. A comprehensive electrical protection system shall be provided to protect the incomer as well as outgoing feeder. The incomer shall have a KWH meter, ammeter, voltmeter etc.

9.2.8 There shall be a separate control panel to control the auxiliaries, and comprehensive alarm and fault indication system shall be provided to indicate the status of auxiliaries as well as Diesel Generator Sets.

9.2.9 DG Set shall be supplied with day oil storage tank of capacity suitable for 24 hour continuous operation at full load, bulk oil storage tank, associated piping, valves, accessories, earthing of all equipment and power and control cables as required.

9.2.10 Emission from DG Set shall meet the requirement of Local Pollution Norms.

9.2.11 DG Set shall be provided with suitable acoustic enclosure to restrict the noise level to 85 dB at 1 metre.

9.2.12 DG Set shall be provided with digital multifunctional meter with communication port for energy management at remote location. Additionally digital type ammeter, voltmeter and Hour Meter shall be provided separately.
9.2.13 Bare minimum protection devices for DG Set have been as indicated below; however LSTK contractor shall provide any other necessary protection relays required for complete protection of system.

Differential, Stator Earth Fault, Rotor Earth Fault, Phase Failure, Over Current (Voltage Restraint), Over Voltage, Winding Temp. Alarm, Bearing Temp. Alarm, Under Frequency, Over Frequency, Reverse Power. A microprocessor based composite generator management relay shall be used for the above mentioned protections. All Numerical Relays and DG set management relays should have dual IEC 61850 communication port for hook-up with LMS.

9.2.14 Complete System shall be separate for each DG Set. Only DG Distribution Board shall be Common.

9.2.15 Following signals for Emergency DG system shall be taken through hard wired/ communication to LMS in addition to various Electrical parameters viz. KW, KVAR, PF, etc.

- DG Set breaker ON/OFF status
- Auto/Manual switch position status
- DC control supply failure
- Tripped on fault
- Generator voltage & current
- DG set run hours
- Number of starts & number of consecutive starts (i.e. DG set auto start blocked due to exhaustion of consecutive starts)
- Day tank diesel level

9.2.16 For all other specification refer PC150-TS-0831.

9.3 Power Transformers

9.3.1 The transformers shall be double wound, copper conductor, and Dyn11 type. Transformers shall rated for 11/3.45 kV, 11/0.433 kV, 3.3./0.433 kV, as required. Transformer with 3.45 kV Secondary winding shall be considered for the substation only, where 3.3 KV switchboard is to be installed for feeding 3.3 KV motors.

9.3.2 The rating of power transformers shall be selected on the basis of load and future load growth. For future load growth the following provision shall be made:

- 25% spare capacity in HV transformers above continuous peak load.
- 30% spare capacity in LV transformers above continuous peak load.

9.3.3 The rating of power transformers shall be selected keeping following into considerations:

(a) Duty : Continuous
(b) Outdoor type : ONAN/ ONAF (ONAN rating shall have 25% spare capacity above continuous peak load. ONAF rating shall be minimum 15% above ONAN rating).
(c) Indoor type : Dry Type
   Epoxy cast resin/ resin encapsulated type
(d) Maximum loading : 80% when one of the transformers is out of service
(e) Peak efficiency at : 35% - 40% of load
(f) Class of Insulation : B or better for oil filled
   : F or better for dry type
(g) Tap changer : OFF load type for less than 10 MVA
   : ON load type for 10 MVA & above

9.3.4 Maximum temperature rise over ambient of 50 Degree Celsius shall be limited to:
(a) Outdoor transformers:
Top oil (measured by thermometer) : 50 °C
Winding (measured by resistance) : 55 °C

(b) Indoor transformers:
Winding (by resistance method) : 90 °C or lower as permissible for class of insulation offered

9.3.5 Special consideration shall be given in specifying the percentage impedance of the transformers to suit the switchgear short-circuit capacity available.

9.3.6 Transformers generally up to 10 MVA shall have ONAN cooling, while ratings above 10 MVA shall be ONAN/ONAF cooled. Bare minimum protection devices for transformer have been as indicated below; however LSTK contractor shall provide any other necessary protection relays required for complete protection of system.

Primary Side.
IDMTL Over Current, IDMTL Earth Fault, High Set Over Current, Instantaneous Earth Fault, Standby Earth Fault, Restricted Earth Fault, Differential (for sizes of 5 MVA and above), *Buchholz Alarm and Trip,*Winding Temperature Alarm,* Trip, *Oil Temperature Alarm, *Oil Level Alarm & Trip, *Trip for Winding Temperature and Oil Temperature. All protection except REF shall be provided on secondary side, if the primary side circuit breaker is located in other sub-station. REF protection shall trip the primary Inter-tripping of primary and secondary circuit breaker of transformer shall be provided for all faults through lockout relays.

CT for Restricted Earth Fault protection shall be provided in the transformer.

9.3.7 Nitrogen Injection Fire Prevention and Extinguishing System (NIFPES) shall be considered for transformers having oil capacity more than 2000 Ltrs.

9.3.8 Following Push buttons shall be provided for transformers:
- Lockable ‘OFF’ push button in transformer room to trip the breakers on primary side.
- Push button shall be provided on breaker on secondary side for permission to close breaker on primary side
- Emergency trip PB on breaker on secondary side for tripping breaker on primary side of transformer.

9.3.9 The instruments such as OTI/WTI, Buchholz relay and MOG shall have Magnetic Reed Switches. The mercury switch contacts are not acceptable.

9.3.10 For all transformers, conservators shall be provided with Magnetic Oil Gauge (MOG) having 1NO contact activated on Low oil level. For transformers where the oil capacity is more than 2000 Ltrs, Air cell shall be provided in the conservator.

9.3.11 Transformer rooms shall have slab and shall be under shed.

9.3.12 Routine test on all transformers and heat run test on one transformer of each rating shall be performed in presence of Owner/Consultant.

9.3.13 All Routine, Heat Run Tests shall be performed in compliance with B.S.171, IEC publication No.60076, IS 2026 (parts I to V), CBIIP and IS: 2026 (Part III) including SFRA Test before dispatch from Manufacturer’s works and at erection site during commissioning or latest editions or any other authoritative standard. Certificates for Type Tests on similar type Transformers shall be submitted.

9.3.14 All Power transformers above 5 MVA shall have facility for Remote display (in LMS) of Oil Temperature, Winding temperature, Conservator Oil Level and moisture ppm of Oil through 4-20 mA signal / Modbus communication.
9.3.15 For all other specification refer PC150-TS-0803.

9.4 **Neutral Earthing Resistor (NER)**

9.4.1 The NER shall be provided to earth the neutral of 11 KV and 3.3 KV systems. Neutral of 415V supply system shall be solidly earthed.

9.4.2 Neutral earthing resistor shall be outdoor type made of AISI 304/406 punched stainless steel grid element. The earth fault current of 11 KV & 3.3 KV shall be limited to full load current of transformer or 400 A, whichever is less.

9.4.3 All NER not requiring operation shall be provided with isolator.

9.4.4 For all other specification refer PC150-TS-0804.

9.5 **Switchboards**

9.5.1 General

9.5.1.1 There shall be three positions for Breaker/Contactor trolley: - Service, Test and Isolate. In service position, the power connections shall be made; but in test and isolate mode, the power connection of bus bars shall be automatically removed.

ACB feeder for PCC, PMCC & MCC shall be single front for ease of operation & maintenance. Non-ACB feeders for motors or power may be double front type.

Breaker duty cycle shall be O-0.3sec-CO-3min-CO.

Separate CT shall be provided for differential/REF protection.

LV circuit breaker shall be 4 Pole type except for outgoing motor feeders which shall be 3 Pole type.

9.5.1.2 Suitable shutter arrangement shall be provided to protect the person from accidental contact with live bus in trolley chamber.

9.5.1.3 The degree of protection shall be IP 4X for HV switchboards and IP 52 for LV Switchboard up to 1600A rating and IP-4X for LV switchboards above 1600A rating.

9.5.1.4 All HV, MV & LV Switchboards shall be LOTO compliance.

9.5.1.5 11 kV & 3.3 kV Switchboard shall conforms to IS/IEC 62271-200, IAC-A FLR-50KA/40KA 1 Sec, PM, LSC 2B which means that the switchgear panels shall be four side internal arc tested, shall have metal partitions and shall confirm to loss of service continuity. LV switchboard shall conform to IEC 60947.

9.5.1.6 LV switchboard (EPMCC/PMCC/MCC) shall be TOTAL TYPE TESTED (TTA) design as per IEC 61439-1/2. Type Test Certificates for short circuit withstand of 50kA for 1 sec along with ACB mounted in the Switchboards shall be provided.

9.5.1.7 LV switchboard (EPMCC/PMCC/MCC) shall comply with Internal Arc Containment test as per IEC 61641.

9.5.1.8 The busbars and connection shall be made of electrolytic grade copper only. Aluminium busbars are not acceptable. All busbars of 11kV & 3.3kV switchgear including bus duct shall have Raychem sleeving.

9.5.1.9 Clearance between gland plate to cable termination point in all switchboards shall be adequate but not less than 300mm to ensure proper cable termination.

9.5.1.10 FRP supports shall be used for bus bars with adequate clearances and creepage distance to prevent flash over due to effect of dust moisture.

9.5.1.11 Protective relays shall be mounted on the front of the switchgear panel.

9.5.1.12 All logic like, Auto/Manual changeover etc. shall be build in the Numerical relay. Adequate number of I/Os shall be provided to meet the requirement. 10% spare I/Os shall also be provided. External I/O Card/ Module is not acceptable.
9.5.1.13 All relays used for protection shall be microprocessor based numerical type only with latest communication protocol IEC-61850 and shall have large graphical display. All relays shall have coating for protection against harsh environment conditions. All numerical relays shall be of one make only. Selected models of numerical relays shall have metering, control, status and protective functions. It shall be possible to save minimum 5 records of each event.

9.5.1.14 LSTK contractor shall supply minimum 1 No. laptops with licensed software for communication & configuration of all make & Type of Numerical Relays.

9.5.1.15 GPS system and associated hardware & software shall be provided for synchronisation of clocks of numerical relay and metering LA & LMS

9.5.1.16 All meters shall be digital multifunctional meters with backlight LCD display and communication port. Additionally digital type ammeter, voltmeter and Hour Meter shall be provided separately for various feeders as indicated above.

9.5.1.17 All the motor / capacitor feeders controlled through vacuum circuit breakers shall be provided with surge arrestors. Lightning Arrestor (LA) shall be provided on each bus of 11KV Switchboard.

9.5.1.18 A continuous ground bus shall be provided at the bottom of the switchgear and in cable connection side for grounding the switchgear, breaker trolley as well as to ground the cable glands.

One no. breaker handling trolley shall be provided for the switchboards as below:
   a) Each HV switchboard.
   b) Each LV switchboard.

9.5.1.19 11KV & 3.3KV Breaker shall be with Integral Earthing switch system with proper interlocks.

9.5.1.20 Control supply bus and space heater supply bus-bars (Copper) of adequate rating shall be provided throughout the length of switchboards with as many sections as sections in power bus-bars.

9.5.1.21 Control supply shall be tapped from control bus in each cubicle/ panel itself through DP MCB of suitable rating.

9.5.1.22 The minimum thickness of sheet steel used in HV and LV switchgear including charger, UPS, ASPB etc. shall be as under:-
   a) Base Channel minimum 3.0 mm
   b) Load Bearing Members minimum 2.0 mm
   c) Doors and covers minimum 1.6 mm

9.5.1.23 A bottom channel of not less than 100 mm shall be provided.

9.5.1.24 The maximum height of the switchboard and other control panels shall be limited to 2200 MM. Maximum height of component requiring operation shall be limited to 1800MM.

9.5.1.25 The switchboards shall have adequate short-circuit ratings and be suitably sized for the load and spare capacity foreseen. The short time rating of bus bar shall be 3 seconds for HV switch boards and 1 second for other boards.

9.5.1.26 The HV switch boards and power control centres shall normally have four spare circuit breaker panel (size shall be as per largest outgoing feeder breaker), two on each side of bus-section.

9.5.1.27 For other boards (PMCCs, MCCs, MLDBs, ASPBs, DCDBs etc.) sufficient number of spare feeders to the extent of min. 20% for each type & rating shall be provided.

9.5.1.28 The 415V switch boards shall have PVC insulated bus bar system suitable for rated voltage. At joints of these bus bars removable shrouds shall be provided.
9.5.1.29 All HV & LV Switchgear, UPS, Battery Charger etc. shall have designated space in each Bus section for Network Switches and other communication equipments.

9.5.1.30 For interfacing with DCS system, separate marshalling panels (with 20% spare terminals) shall be provided on each bus section in all HV & MV switchboards in the same panel line-up. The marshalling panels shall be of full height same as that of switchboards. The horizontal bus bar chamber at the top shall be continuous through this marshalling panel also, for future extension of the MV switchboard. All critical control signals for DCS interface shall be hardwired between substations and DCS. Other non-critical data of Electrical system will be sent to DCS with redundant communication facility between DCS and LMS.

Hardwired signals (with minimum requirement specified below) from various Motor feeders of a bus section for DCS interface shall be wired and terminated in the marshalling cabinet:
- DCS Start permissive
- Process Start command (Auto)
- Remote Start command (Manual)
- Process Stop command
- Process Trip command (for breaker controlled motor feeder)
- Breaker/Contactor ‘ON’ indication
- Breaker/Contactor ‘OFF’ indication
- Ready to Start indication
- Electrical Fault Trip indication

9.5.1.31 Following monitoring signals, as a minimum, shall be taken from substation to DCS interface, through redundant MODBUS SERIAL LINK communication from LMS system.
- Load Data viz. KW, PF, A, etc.
- L/R indication
- Process Trip indication
- Electrical Fault Trip indication
- Trip Details

9.5.1.32 Auto changeover scheme shall be provided for incomers and bus couplers on all 11 KV switch boards, 3.3 KV switch boards and PMCCs/PCCs/ MCCs. Under normal operating conditions, incomer-1 and incomer-2 breakers would be closed and bus coupler breaker would remain open with ‘auto-manual’ switch in ‘auto’ position. The bus coupler switch would close automatically under the following condition being fulfilled:
  i. Either of the incoming breaker trips due to under voltage (70% or below).
  ii. Voltage on the healthy bus is more than 80% for the set period.
  iii. Residual voltage on the bus with no power supply comes down to 30%.
  iv. Auto change over shall be locked on loss of power on both the incomers.

Auto changeover shall also be provided on switchboards catering to emergency loads.

9.5.1.33 Paralleling of two incoming feeders is not foreseen. However, facility for momentary paralleling shall be provided for intentional changeover without interruption of supply.

9.5.1.34 Every enclosure door that provides access to live parts operating at 240 V AC and above shall be mechanically interlocked with a circuit interrupting device on the supply side such that when the door is open, the equipment is de-energised.

9.5.1.35 Separate redundant AC and DC control supply shall be provided for each Switchboard.

9.5.1.36 Control supply for motor feeders having MCCB in PMCC/MCC and VFD panels etc. shall be feed from 240V UPS (Electrical) and motor controlled with breaker shall have 110 V DC control supply irrespective of its being HV or LV.

9.5.1.37 For motors with auto-starting provision, trip of a running motor shall start standby motor automatically.
9.5.1.38 All the HV/LV switchgear shall be fed through two separate transformers, each transformer having capability to take care of 100% load of the associated switchgear and shall have the facility of auto changeover in case of failure of one transformer as well as option of manual changeover for maintenance purpose.

9.5.1.39 Max. 3 runs of 400 sq.mm power HV cable shall be terminated in single panel. For more than 3 runs of cable complete dummy/adaptor panel shall be provided.

9.5.1.40 The CB ON and OFF lamp shall be provided at rear and front side of 11kV/3.3kV switchboards.

9.5.1.41 All breakers service ON/OFF contact multiplier contactors shall be mechanically latched type and independent of control supply. Loss of supply and restoring the supply shall not affect the status of the relay/ contactor.

9.5.1.42 All breakers shall be electrically operable and mechanical operation from the breaker shall be possible locally. Manual breakers are not acceptable.

9.5.1.43 Separate Ammeter shall be provided for panel and motor feeder Space heater circuit for each panel.

9.5.1.44 The terminal strips used shall be of stud and nut type and control wiring shall be done with ring tong lugs only.

9.5.1.45 Dual channel output with display type current transducer for all HV and LV switchboard feeder shall be provided requiring Ammeter at control panel.

9.5.1.46 All motor (HV/LV) power feeders shall have separate earth fault protection through CBCT and earth fault relay. LV motor (above 5.5. KW) and power feeder above 100A shall have CBCT and Digital earth leakage relay with display.

9.5.1.47 All external hardware shall be of stainless steel only.

9.5.1.48 The control compartment and power compartment shall be separate.

9.5.1.49 All HV and LV breakers shall have remote switching facility as well as ON/OFF/TRIP indication at LMS.

9.5.1.50 Following Set of accessories as detailed below shall be provided for each 11kV/3.3 kV Switchboard :
   a) Breaker handling trolley – 2 Nos.

   Following Set of accessories as listed below shall be provided for each 415 V Switchboard :
   a) Breaker lifting and handling trolley : Minimum 2 nos.
   b) Test cabinet with coupling cables for testing the breaker in draw out position : Minimum 1 No.
   c) Racking in/out handle for breakers : Minimum 4 nos.
   d) Racking in/out handle for draw out MCC modules : Minimum 2 for each MCC

9.5.1.51 Alarm relays with reverse flag shall be provided to annunciate failure of main incoming A.C. and D.C. power supplies and annunciation D.C. supply in each panel. Lamp indications shall be provided individually for main D.C. supply-1 fail, main D.C. supply-2 fail, and panel annunciation D.C. supply fail. A common A.C. electric bell shall be provided to give an audible alarm in case of failure of D.C. supply-1/D.C. supply-2/annunciation D.C. supply in any panel. A common push-button shall also be provided for cancellation of lamp indications and audible alarm.

9.5.1.52 Gland plate for single core cables shall be non-magnetic.

9.5.1.53 For all other specifications, refer PC150-TS-0805, PC150-TS-0806, PC150-TS-0808 and PC150-TS-0809.
9.5.1.54 Separate panel shall be considered for incomer Line PT & Bus PT (11 kV & 3.3 kV Switchboards) and PT shall be draw out type. 4 pole MCB shall be provided on LV side of Bus & Line PT.

9.5.1.55 Inspection window shall be provided for HV termination in the switchboard for carrying out thermography, provided internal arc test certificates for this design is available with the bidder.

9.5.1.56 All Incomers and bus couplers shall be provided with synchronising facility. Synchrocheck relay shall be provided in each bus PT & contacts shall be multiplied and wired in each outgoing feeders of each bus section.

9.5.1.57 All 11kV, 3.3 kV and 415 V Switchboards shall preferably be of same make for ease of operation & maintenance.

9.5.1.58 Supervision of installation, testing and commissioning including testing of Relays of all switchboards shall be done through OEM only.

9.5.1.59 All Cable Differential Relays shall be FO Cable type only. Supply & termination of the FO cable & associated HDPE duct, as required, for feeder differential protection shall be included LSTK Contractor’s scope.

9.5.1.60 All Numerical Relays shall be of same Make and Model (series).

9.5.1.61 11kV & 3.3kV Circuit Breaker shall have integrated earth Switch with proper Mechanical & Electrical Interlocks.

9.5.1.62 11kV & 3.3kV Breaker rack in rack out facility should be operable when breaker panel door is closed position.

9.5.1.63 LV Switchgear design shall be such that the feeder doors should not open in locked out tagged out condition.

9.5.2 11 KV Switchboard

9.5.2.1 The 11 KV switchboard shall be indoor, metal enclosed, draw out type, equipped with VCBs, stored energy mechanism working on 110 V DC and shall feed power to the various substations through transformers and other outgoing feeders.

9.5.2.2 Degree of protection shall be IP4X as per IS/IEC 60529,IEC 60298. Switchgear sizes and configuration shall be rationalized to minimum spare holding.

9.5.2.3 A study shall be conducted by LSTK Contractor to determine the rated short circuit capacity for the selection of equipment. However, Rated short circuit breaking capacity shall be as determined by the study or 40 KA for 3 sec, whichever is higher. HV Switchboard shall be suitable for Internal Arc (AFLR) withstand current of “rated short circuit current” for 1 sec.

9.5.2.4 Incoming, bus coupler and outgoing feeders shall be provided with ON, OFF, Trip, Trip Circuit Healthy indications. Process trip lamp/annunciator window to be provided wherever applicable.

9.5.2.5 Control supply shall be 110 V DC.

9.5.2.6 Extra anti-condensing space heater shall be provided in Bus –Bar and Cable chamber of 11KV Switchboard.

9.5.1 3.3 KV Switchboard

9.5.1.1 The 3.3 KV switchboard shall be indoor, metal enclosed, draw out type, equipped with Vacuum Circuit Breakers (VCBs), stored energy mechanism working on 110 V DC. for all feeders.

9.5.1.2 The minimum degree of protection shall be IP4X as per IS/IEC 60529,IEC 60298. Switchgear sizes and configuration shall be rationalized to minimum spare holding.

9.5.1.3 A study shall be conducted by LSTK Contractor to determine the rated short circuit capacity for the selection of equipment. However, rated short circuit breaking capacity shall be as
determined by the study or 26.24kA for 3 sec, whichever is higher. HV Switchboard shall be suitable for Internal Arc (AFLR) withstand current of "rated short circuit current" for 1 sec.

9.5.1.4 Incoming, bus coupler and outgoing feeders shall be provided with ON, OFF, Trip, Trip Circuit Healthy, Spring Charged indications. Process trip lamp/annunciator window to be provided wherever applicable.

9.5.1.5 Control supply shall be 110 V DC.

9.5.1.6 Extra anti-condensing space heater shall be provided in Bus –Bar and Cable chamber of 3.3KV Switchboard.

9.5.2 Low Voltage Switchgears

9.5.2.1 415 V switchboards shall include the following:
   a) Power Control Centres (PCCs)
   b) Power-cum-Motor Control Centres (PMCCs)
   c) Emergency Power-cum-Motor Control Centres (EPMCCs)
   d) Motor Control Centres (MCCs)
   e) Main Lighting Distribution Boards (MLDBs)
   f) Auxiliary Services Power Boards (ASPBs)
   g) Emergency Power Distribution Boards

   EPMCC shall be separate from PMCC.

9.5.2.2 Low voltage switchboards shall be metal clad, arranged with self supporting units and assembled together in a row. The degree of protection shall be IP 52.

9.5.2.3 Internal physical separation / segregation of 415 V Switchboards shall be 3 B for Non-ACB feeders and 4 B for ACB feeders.

9.5.2.4 The switchboards shall be suitable for extension at both the ends.

9.5.2.5 Bus bars shall be of uniform cross section and supported on non-hydroscopic FRP insulators with adequate clearances and creepage distance to prevent flash over due to effect of dust/moisture.

9.5.2.6 The horizontal busbars as well as vertical droppers of LV switchboards shall have heat shrinkable insulated sleeves.

9.5.2.7 Sufficient bus supports shall be given to give adequate mechanical strength during short circuits.

9.5.2.8 A continuous ground bus shall be provided at the bottom in the PCC/PMCC/MCC for grounding the PCC/PMCC/MCC.

9.5.2.9 Rated short circuit breaking capacity shall be 50 KA for 1 sec.

9.5.2.10 The PCC, MCC, Main lighting distribution board and auxiliary services power board shall be provided with withdraw able air circuit breakers for incoming feeders and bus ties.

9.5.2.11 All ACBs shall be electrically operated- EDO type only. Manual breakers are not acceptable. Each electrically operated breaker shall be provided with antipumping (94), Breaker fail (52BF) and trip free feature, trip annunciation (30) and lockout (86) relays. Lockout relay shall be hand reset type.

9.5.2.12 All ACBs shall be without any internal releases. The required protections shall be wired by means of external numerical relays.

9.5.2.13 Motor feeders up to 75 KW rating shall be contactor controlled and above 75 KW, these shall be ACB controlled with combined motor protection relay. All other feeders of 415 V
switchboards shall be provided with MCCB. All outgoing feeders shall be draw-out type in all the switchboards.

9.5.2.14 Switchboards shall be provided with thermostatically controlled anti-condensation heaters.

9.5.2.15 All units in the MCC shall be completely accessible and removable from front. Both power and control connections shall be stab-in type.

9.5.2.16 Bus bar clearances shall conform to relevant Indian Standard/IEC for equipment voltages up to and including 500 V AC.

9.5.2.17 The switchboards shall be compartmentalized and individual feeder modules shall be draw-out type. Fixed type modules shall not be acceptable.

9.5.2.18 The draw out modules shall be standardized and it shall be possible to interchange any module with a module of same size. The components to control the equipment like MCCB, starter, auxiliary relay etc. shall be wired as a unit on the individual module. Safety shutter shall be provided to prevent direct access to live parts when the chassis is removed.

9.5.2.19 The entire draw out construction should be designed for safe operation during placement or removal of chassis. An earthing arrangement shall be provided which will make contact first before the power contacts are made and break last. Each module shall control one motor in general.

The door shall be interlocked so that it cannot be opened unless the isolating switch on that module is OFF. However, it shall be provided with a door defect mechanism for intentional opening when on line for testing and inspection purpose.

9.5.2.20 Control switches for breaker control shall be provided in each breaker cubicle. Circuit breaker shall be interlocked to prevent withdrawal of a closed breaker or insertion of a closed breaker. Each breaker shall be provided with anti pumping device.

9.5.2.21 Provisions shall be made to manually close/trip circuit breakers on loss of control voltage.

9.5.2.22 The LV PMCC/MCC/PCC control supply shall be 240VAC, 50Hz UPS supply fed from UPS Distribution Board of Separate 240 V AC UPS System dedicated for MCC control supply; Control Room & Substation lights, LMS Equipment, Fire Detection & Alarm System etc. Breaker control supply shall be 110V DC.

9.5.2.23 All low voltage switchboards shall be provided with 20% spare outgoing feeders or minimum one of each rating (fully wired) and with all the components.

9.5.2.24 The timers shall be electronic type only. Pneumatic or synchronous type timers are not acceptable.

9.5.2.25 Each outgoing motor feeder shall consist of a number of components mounted in a module duly wired. In general outgoing feeder rated below 75 KW shall consist of:

a) MCCB.
b) Control supply On/Off switch and fuse
c) Power Contactor
d) Electronic Digital Motor Protection Relay with built-in Earth Fault, Overload, Stalling, Single phase protection, etc. Thermal Overload Relay are not acceptable.
e) C.T for metering
f) Overload reset button.
g) Process Trip / ON / OFF indicating lamp with separate indicator fuse.
h) Auxiliary contactors for multiplication / control.
i) Test position limit switch and test PB
j) CT operated Ammeter for all motor feeders above 1.5 KW, all MOV and LOPs at both LCS and Feeder end.

k) Selector switches as per requirement.

9.5.2.26 Provision for indication of minimum following electrical parameters in 415V PCC / PMCC/ MCC shall be made:

a) ON OFF, TRIP, TRIP CIRCUIT HEALTHY, TEST, SERVICE Position, indication in ACB feeders.

b) The KWH meters on incomers shall have provisions for sealing for tariff purpose, as required.

c) MCC shall conform to the following as a minimum:
   - Motor starters rated for utilisation category AC3 and protection equipment with a minimum of type 2 co-ordination.
   - The number of modules per tier shall not exceed 6.
   - MCC incomer sizes and configurations rationalised to minimise spares holdings.

9.5.3 Auxiliary Supply Power Board

The ASPB shall generally be single front, floor mounted draw out type having essential and non-essential bus. Non-essential bus shall be disconnected in case of failure of normal supply through a contactor. Each Substation station shall have separate ASPB.

9.5.4 Lighting Sub Distribution Boards

The Distribution Boards shall be single front, non-draw out wall mounted type.

9.5.5 UPS Distribution Boards

9.5.5.1 The UPS Distribution Boards shall be single front, floor mounted non-drawout type for supply of 115 V AC / 240 V AC.

9.5.6 Direct Current Distribution Boards

9.5.6.1 The Direct Current Distribution Boards (DCDBs) shall be single front, floor mounted non-drawout type for supply of 110 V DC control power to switchgears and panic lighting. Each Substation station shall have separate DCDB.

9.5.6.2 Following potential free contact shall be available for each Motor feeders for indication in LMS in addition to process requirement:

   • Motor ON
   • Motor OFF
   • Motor Process Trip
   • Motor Elect Trip

9.6 Motors

9.6.1 The rating of LV and HV motors shall be selected from the sizes as recommended in relevant Indian Standard/IEC.

9.6.2 The margin between the installed power and absorbed power shall be as recommended by the driven machine supplier but shall not be less than the following:

<table>
<thead>
<tr>
<th>Motor Rating</th>
<th>Margin above Driven M/C Absorbed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 22 KW</td>
<td>25%</td>
</tr>
<tr>
<td>22 KW to 55 KW</td>
<td>15%</td>
</tr>
<tr>
<td>75 KW and above</td>
<td>10%</td>
</tr>
</tbody>
</table>
9.6.3 Voltage Ratings:

Voltage rating for the motors of different ratings shall be as below:

- Upto 150 KW: 415 V, 3-phase, 50 Hz AC
- Above 150 KW - 1000 KW: 3.3 KV, 3-phase, 50 Hz AC
- Above 1000 KW: 11 KV, 3-phase, 50 Hz AC

All motors shall be designed for 3-Phase supply only.

9.6.4 The motors shall have maximum continuous rated duty S1 as per relevant Indian Standard/IEC. Rated duty for special duty motors wherever required e.g. cranes etc. Shall be considered as per driven equipment requirement.

9.6.5 All LV motors shall be TEFC type as per relevant Indian Standards/IEC while HV motors shall be TEFC/CACA type. All motors shall be Class-F insulated with temperature rise limited to that of Class-B.

9.6.6 Normally the motors shall be suitable for DOL starting. However, motors started through VFD shall be suitable to run at 30% to 100% of rated speed and compatible with the VFD.

9.6.7 All motors 30 KW and above shall have space heater provision.

9.6.8 All HV motors shall have winding, hot air and bearing RTDs. All the temperature signals shall be terminated to DCS as well as LMS.

9.6.9 All LV motors shall be of efficiency class 'IE3' as per latest applicable version of IS: 12615. All HV Motors shall be of high efficient and high power factor type.

9.6.10 The starting current i.e. breakaway current of 415 V Motors shall not exceed the values indicated in IS: 12615. Also there shall be no further positive tolerance on the values of breakaway current.

9.6.11 The starting current of 11 KV & 3.3 KV motors shall not exceed 550% of FLC. No positive tolerance is acceptable over 550% FLC.

9.6.12 Type test certificate of similar motor for use in specified hazardous area (if applicable) shall be furnished.

9.6.13 The duty cycle of the motor shall meet the process and driven machine requirement.

9.6.14 In case of 11 KV & 3.3 KV motor, the terminal box shall be suitably designed for proper termination of XLPE insulated Aluminium cables through heat shrink termination kit.

9.6.15 The mechanical parameters such as duty, mounting type, shaft extension, direction of rotation, starting torque requirements etc. shall be adequate for the application. Sleeve or anti friction type bearings shall be used. Vertical motors shall have thrust bearings suitable for the load imposed by the driven machinery. Motors with sleeve bearings may require proximity probes to measure shaft vibration adjacent and relative to the bearings.

9.6.16 Motor rated above 30 KW shall have on line greasing provision and for motor rated above 45 KW, grease outlet feature shall be provided.

9.6.17 All HV motors shall have safety factor not less than 1.1.

9.6.18 Motors rated 1000 kW and above shall have suitable measures to prevent flow of shaft currents and shall have 2 sets (i.e. 6 nos.) of PS class CTs for differential protection.

9.6.19 The motor shall be capable of withstanding the electro dynamic stress and heating imposed if it is started along with the driven equipment at voltage of 110% of the rated value.

9.6.20 During starting of large motor, the voltage may drop to 80% of the rated voltage for a period of 60 seconds. All electrical equipment, while running, shall successfully ride over such period without affecting system performance.
9.6.21 D.C. motor provided for emergency service shall be shunt/compound wound type. Motor shall be sized for operation with fixed resistance starter for maximum reliability.

DC starters shall be complete with MCCB, contactors, resistors, relays, meters, push-buttons, lamps, etc. DC contactor shall be Class I – Category DC3. Switch Duty shall be DC22. The resistor enclosure shall be provided with ventilating louvers and wire mesh guard and shall have a degree of protection IP-23.

9.6.22 The motor may be subjected to sudden application of 150% rated voltage during bus transfer, due to the phase difference between the incoming voltage and motor residual voltage. The motor shall be designed to withstand any torsional and/or high current stresses, which may result, without experiencing any deterioration in the normal life and performance characteristics.

9.6.23 Shaft voltage shall be limited to 200 mV.

9.6.24 For all other specifications, refer PC150-TS-0810.

9.7 **Rectifier-cum-Battery Charger**

9.7.1 The Rectifier-Cum-Battery Charger shall be fully automatic using silicon controlled rectifier and shall consist of units as described below:-

i) Main Float cum Load charger: To supply continuous load and keep the battery in healthy state.

ii) Standby Float cum Load charger: To supply continuous load & keep the battery in healthy state in case any abnormality in Main charger.

iii) Boost charger: To charge the battery set initially and recharge (after meeting emergency or sudden application of heavy loads.)

9.7.2 Battery Charger shall have at least 20% extra capacity for future load requirement. Battery Charger shall have 110 V DC system.

9.7.3 Separate Rectifier-Cum-Battery Charger with DC Distribution Board and Battery Bank shall be provided for each Substation.

9.7.4 Each substation shall be provided with redundant battery charger with 2x100% battery banks and connected to each Charger.

9.7.5 The battery and charger combinations shall be such as to ensure continuity of D.C. supply at load terminals without even momentary interruption.

9.7.6 AC Ammeter and AC Voltmeter on Charger Input; DC Ammeter, DC Voltmeter for charger output/ battery voltage and on demand type Battery Charge / Discharge Ammeter shall be provided.

9.7.7 Following analog signals through suitable transducer shall also be provided for hook-up in LMS:

- Status of charging current (float & boost charging)
- Battery current
- Incoming voltage

9.7.8 Following potential free contacts shall also be provided for hook-up in LMS

- DC under voltage
- DC overvoltage
- DC earth leakage
- AC incoming power supply failure
- AC input fuse blown-off
- Thyristor/ diode failure
- DC output fuse blown-off
- DC battery fuse blown-off
9.7.9 For all other specifications, refer PC150-TS-0813.

9.8 Battery Sets.

9.8.1 These shall be Ni-Cd Battery Sets shall be rated to meet the total DC power requirement for 5 hour after complete power failure.

9.8.2 Spare capacity of 20% for future use shall be considered.

9.8.3 Battery shall be designed with minimum temperature as 5°C.

9.8.4 For all other specifications, refer PC150-TS-0814.

9.9 Uninterruptible Power Supply System (UPS)

9.9.1 115 V AC UPS System with UPS Distribution Board shall be provided to feed 115 V AC, 50 Hz, 1Phase power supply to the instrumentation system, DCS etc. This UPS System along with associated Battery and UPS distribution Board shall be located at Control Room. Separate 240VAC UPS System with UPS Distribution Board shall be provided to feed PMCC & MCC control supply, Control Room & Substation lights, LMS Equipment, Fire Detection & Alarm System etc. This UPS System along with associated Battery and UPS distribution Board shall be located at Substation. Block Diagram of 115 V UPS System shall be followed but with 240 V in place of 115 V.

Both 115 V AC UPS System and 240 V AC UPS System complete with Battery, UPS Distribution Board etc. shall be separate.

9.9.2 The UPS System shall have IGBT type with touch screen LCD display and shall be backed up by nickel cadmium (Ni-Cd) battery rated for 2 hour at rated capacity of the UPS. Battery (100% Capacity) shall be separate for each Inverter.

9.9.3 UPS system construction shall be such that each charger, inverter module can be made fully isolated for maintenance. No common devices/wiring shall be installed. Further there shall be no common device between main & redundant units (e.g. master oscillators etc.) in order to ensure that the failure of the same does not cause shutdown of more than one unit.

9.9.4 UPS system shall have facility for built in Online battery bank monitoring & testing facility for displaying/calculating expected battery bank back-up time (during testing if battery bank does not have sufficient back up time, test shall be terminated & load shall be shifted to charger automatically).

9.9.5 UPS shall be suitable for 100% step load.

9.9.6 Battery Load cycle test shall be carried out by the vendor at site.

9.9.7 The UPS rating shall be such that in any case the load on the individual UPS shall not exceed 40% of the rated capacity.

9.9.8 The over load capacity of UPS shall be 200% for 10 cycles, 150% for 60sec & 125% for 10min.

9.9.9 All four sections, i.e. Rectifier-I, Rectifier-II, Bypass – I and Bypass - II shall be fed through four separate feeders of emergency bus of PMCC.

9.9.10 UPS shall be PWM based using IGBT. Each charger and SCVS shall have isolating transformer at the input.

9.9.11 The salient features of the UPS shall be as under:
   a) High Efficiency
b) Compatible to feed nonlinear, high crest factor loads

c) Microprocessor based monitoring system for UPS status and fault indications

d) High transient performance

e) Low audible noise

9.9.12 Each UPS shall be provided with SNMP software so that all the parameters of UPS and alarms/faults can be viewed into the remote computer. These logs/trends of load can later be printed. Web based parameter and status monitoring shall be used. It shall be hooked to LMS and DCS System.

9.9.13 The transfer time of UPS from inverter to bypass, in case of failure of both inverters, shall be so selected that during this transition period, instrumentation/DCS etc. which leads to tripping of plant shall not fail. Typically, it shall be as below:

- In synchronism: No break transfer i.e. within 6 milliseconds (Maximum)
- In asynchronous mode: Within 16 milliseconds (Maximum).

9.9.14 The technical parameters of UPS shall be as under:

Input

a) Rated Voltage 415 V ± 10%

b) Rated Frequency 50 Hz ± 5%

Output

a) Rated Voltage 115 V AC / 240 V AC

Voltage regulation:

- Static (0-100% load) ±1%
- Dynamic for 100% load change: ±5%

9.9.15 Following potential free contacts shall be made available on the UPS,

- Rectifier ON
- Inverter ON
- Battery CBB ON
- Load on Inverter
- Inverter fail
- Rectifier Fail
- Inverter O/P undervoltage
- Inverter Sync.
- Load on battery
- Bypass Fail
- Load on bypass
- Load transferred, etc

Note: A separate common potential free contact for all the faults/alarms (in UPS / SCVS) shall be made available

9.9.16 Operation Philosophy of UPS:

- 2 sets of rectifiers and inverter shall be provided. Under normal conditions, when AC mains power is available, both the rectifiers shall operate in parallel and supply DC power for float/rapid charging the 2X50% batteries and simultaneously to inverters. In case of failure in one rectifier, the other rectifier shall feed the complete load and the batteries without any interruption.

- In case of Incoming supply failure or failure of both rectifiers the 2X50% batteries shall feed the inverters without any interruption. Each rectifier shall be designed for simultaneously feeding complete inverter load and float/rapid charging of the 2X50% batteries to its rapid capacity. Each rectifier shall be equipped with “On Line” automatic as well as manual charging facility.
• Normally both the inverters will be synchronised with each other and with stabilised bypass supply. Both inverters shall operate in parallel and share the load equally.
• The load sharing controls shall not be subject to common mode failure and any failure of the load sharing controls shall not result in the loss of the vital power.
• When a disturbance/fault occurs in any of the inverters, the faulty unit shall automatically get disconnected and the entire load shall be fed from the other inverter. In case both the inverters develop a fault, the complete load shall be transferred to stabilized bypass supply through the static switches and retransfer of the load from the stabilized bypass supply to the inverter shall be possible in auto as well as in manual mode.

9.9.17 All alarms & status of UPS shall be communicable through Modbus / Ethernet protocol to LMS.

Following minimum shall be considered:
- Load on Inverter
- Load on Bypass
- Load on Battery
- Battery on float/boost charging mode.
- Charger failure.
- Inverter failure
- AC mains failure
- DC under voltage
- DC Over voltage
- Automatic retransfer of load to inverter inhibited.
- Fan failure
- AC Voltage, current & frequency of each inverter
- AC incoming power supply Voltage & voltage.
- DC current at each rectifier output.

9.9.18 For all other specifications, refer PC150-TS-0802.

9.10 Variable Speed Drives (VSD/VFD)

9.10.1 Microprocessor based variable speed drive shall be communicable type and shall be able to communicate with LMS/DCS. It shall be possible to set speed from process DCS for optimum performance through 4-20 mA signal. Speed/current/status feedback to DCS shall be provided. Drive will run at preset speed in the event of loss of signal from DCS.

9.10.2 System shall be highly reliable, efficient and shall provide high power factor, low harmonic distortion, low noise level etc.

9.10.3 System shall be provided with complete by pass circuit to ensure the power supply reliability in case of VSD/VFD failure. It shall be possible to start the motor in DOL mode through bypass system in case there is any problem/fault in the VFD. The Electrical system and the process should be capable to operate the Motor in fixed speed (without VFD).

9.10.4 The system shall be suitable for load characteristics, continuous speed control. Drive shall be able to accelerate the load over the full speed range (0 – 100 %) with incoming line voltage regulation of 10%.

9.10.5 The system shall be designed for 150% over current withstand for 1 minute. The system shall be equipped with an automatic restart facility which will restart the system in case of voltage dip over 20% or power interruptions less than 4 seconds and recovery of voltage to 95% with a facility to block the automatic restart.

9.10.6 The system shall be suitably designed with due care for long length of cables, output filters, chokes, motor insulation, cable voltage grades etc.
9.10.7 The VSD panel shall be located in the clean air conditioned room in the substation. Required local control equipment shall have start, stop speed raise and lower push buttons, ammeter, speed indicator, ON/OFF/READY status selector switches as required and shall be installed near the motor.

9.10.8 The VFD shall be provided with Input and Output transformer. To prevent harmonics in the station supply 12 pulse rectifier shall be deployed at Input of the VFD.

9.10.9 "Auto Restart" facility for drive system within preset time, typically 0-15 seconds, in case of supply system dip or complete loss of power shall be provided.

9.10.10 Preferably screened type cables or cables as recommended by VSD/VFD vendors shall be used for VSD/VFD systems.

9.10.11 The VSD/VFD panels to be supplied shall be of proven model.

9.10.12 Training of VSD/VFD shall be provided to owner personnel.

9.10.13 For all other specifications, refer PC150-TS-0820A and PC150-TS-0820B.

9.11 Soft Starters

9.11.1 Soft Starter may be considered for large sized motors to overcome the problems of voltage drop during starting and also over sizing of transformer and generator. However, VFD shall be preferred over Soft Starter. Soft Starter may be used in exceptional case only after approval of Owner/ Consultant.

9.11.2 The soft starters shall be solid state microprocessor control type with self torque adjustment (during controlled start) feature with bypass contactor. Soft starters shall be communicable type and shall be able to communicate with LMS.

9.11.3 Soft starter shall be designed with starting current limited to 350% to 415% (However Contractor shall ensure that this reduced starting voltage is suitable to develop necessary starting torque requirement of the respective motor). The soft starters shall be designed for the optimum voltage drop during starting such that the drive motor and the load get the required accelerating torque.

9.11.4 Soft starter shall be as per standards IEC 34/BS 4999/IS 325/BS 5000.

9.11.5 The Contractor shall super impose the motor torque vs speed curve at reduced voltage (to motor terminals at starting) on torque vs speed characteristics of the driven equipment to confirm correct operation i.e. acceleration to rated speed. The Contractor shall also calculate acceleration time at reduced voltage (based on these torque vs speed curves) required for accelerating the drive, to full rated speed. This acceleration time shall be sufficiently less than the hot withstand time of the motor.

9.11.6 For all other specifications, refer PC150-TS-0828.

9.12 Local Control Stations

9.12.1 Local Control Stations shall be provided for all motors for testing and maintenance purpose when the selection is made is "LOCAL MODE" Operation. The essential features of the LCS shall be as given below:

9.12.2 LCS shall be pressure die cast aluminium housing (preferably), dust & vermin proof, weatherproof, suitable for wall or pedestal mounting with equipment mounted on a base plate inside and behind a front cover (bolted type).

9.12.3 LCS Enclosure shall be certified for use in hazardous areas.

9.12.4 Provision for pad locking in OFF position shall be provided.

9.12.5 Local control stations for breaker controlled HV and LV motors shall be provided with T-N-C switch, Ready to Start Indication, ON indication, Space Heater ON Indication, Trip Indication, Local-OFF-Remote Control switch and ammeter. Moreover, space heater ON indication lamp, trip indication lamp shall also be provided at the switchgear panel.
9.12.6 Local control stations for contactor controlled LV motors shall be provided with start/stop push buttons, ammeters and Space Heater ON Indication (for motor rated 30KW and above), ON indication, Local-Remote switch (as required) for the motors having rating 5.5 KW and above. If required from process point of view, ammeter shall be provided for motors below 5.5 KW also.

9.12.7 Each element for start and stop shall be provided with 1 NO + 1 NC contact. The push button construction shall be such to avoid mal-operation due to vibrations.

9.12.8 All local control stations shall have weather proof IP-65 enclosure and be suitable for installation in relevant hazardous area, gas group and temperature class. Canopies of suitable size shall be provided with all local control stations.

9.12.9 All components shall be completely wired up to terminal block and also provided with earthing terminals.

9.12.10 Inscriptions on corrosion resistant metal strips giving drive description, mechanism number and functional requirement shall be provided.

9.12.11 Two numbers of LCS shall be provided for the motors, which are installed at elevated platforms, such as cooling tower fan etc. One shall be installed at ground level and the other near the motor.

9.12.12 The ammeter shall be flush mounting, moving iron spring controlled type, of accuracy class 1.5 as per IS: 1248, with square face of minimum size 72 mm × 72 mm having scale range 0-90 degree. The ammeter shall be provided with uniform scale up to CT primary current and compressed end scale up to the 8 times the C.T. primary current. Adjustable red pointer shall be provided to indicate the full load current of the motors. Zero adjusters shall be provided for operation from the front of the meter. All ammeters shall be operated through 1 Amp. CTs only.

9.12.13 Complete Push Button along with its actuator mounted on the cover with wiring done through flexible cables with proper protection.

9.12.14 Preferably Ring Type lug and suitable TB to be used for connection, to avoid loose connection.

9.12.15 All spare hole to be plugged with suitable metal plugs.

9.12.16 For all other specifications, refer PC150-TS-0817.

9.13 Industrial Goods Lifts

9.13.1 Lifts shall have automatic centre opening doors, SS cabin with aluminium chequered plate flooring cabin and steel belts (rope), closed loop VFD. A low – inertia gearless machine with a permanent magnet (PM) synchronous motor, battery-operated rescue system with electronic speed monitoring, machine on the rails to transfer loads down to the pit.

9.13.2 Automatic Rescue Device shall be capable of moving the lift to the nearest landing on main power failure.

9.13.3 Lift Machine room shall be located at ground floor.

9.13.4 Following Control & Indication shall be provided on all landings and ground floor:
- Digital Car position indicator for each lift on top as well as on side wall
- Audio alarm & direction indicator for each lift
- Common up/down call buttons
- Fireman switch
- Braille marking on all buttons

9.13.5 Following Control & Indication shall be provided in car:
- Braille marking on all buttons inside the car
- Voice announcement system with all necessary equipments.
- Appropriate positioning of Car Operating Panel
- Floor selector button
- Emergency stop and alarm button
- Combined digital position and direction indicator.
- Wiring for telephone and telephone instruments (intercom) in lift car, machine room and ground floor, lift lobby
- Lighting, emergency alarm and fan to be provided with emergency supply through inverter having at least half an hour battery backup.
- Car Operating Panel (COP) should be on the front panel as approved by the owner.

9.13.6 Separate minimum 1 No. Lift / Elevator for passenger cum goods of capacity 2.0 Ton shall be provided in each Boiler Area, covering all floors. The location of the Lifts/elevators shall be decided during detailed engineering but the same shall not be located at same place.

9.13.7 No. of level of landing shall be as per operational requirement.

9.13.8 For all other specifications, refer PC150-TS-0827.

9.14 Switch Sockets

9.14.1 Sufficient number of inter-locked type 125A/63A, 415V, 3 Ph and 16A, 240V, 1 Ph switch sockets shall be provided in various plant locations as per hazardous area classification to facilitate the maintenance work. Supply to switch-sockets shall be taken from ASPB through suitably rated RCCB. Minimum 2 Nos. Switch Sockets to be provided in each floor of all Boilers.

9.14.2 Minimum 2 Nos. 24 V 10 A Switch socket shall be provided near all man-hole of vessels for maintenance to which 24 V hand lamps can be connected and carried inside.

9.14.3 Both 3 Phase switch sockets and 1 Phase switch sockets shall be provided at Min. 20 M interval. Maximum 2 Nos. 63A switch sockets and 2 Nos. 16A switch sockets shall be connected in one circuit.

9.14.4 For all Other Specifications, Refer PC150-TS-0811.

9.15 Conduits

9.15.1 Conduits shall be of heavy gauge with minimum wall thickness of 1.4 mm (upto 25 mm dia) and 2 mm (above 25 mm dia) rigid steel, hot-dip galvanized, cut square, reamed, threaded and screwed tight at all joints.

9.15.2 Conduits entrances to pull boxes and switches shall have double lock nuts & insulating bushings. No running thread shall be used.

9.15.3 Flexible metallic conduit shall be used for connection to equipment which are subject to vibration and also for connection to level /limit/pressure switches. Conduit runs shall be supported at an interval of 750 mm for vertical run and 1000 mm for horizontal run.

Conduits shall be sized so that conduit fill (ratio of total cable area to conduit area) shall not exceed the following:

<table>
<thead>
<tr>
<th>Number of Cables</th>
<th>Fill Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Cable</td>
<td>53%</td>
</tr>
<tr>
<td>Two Cable</td>
<td>31%</td>
</tr>
<tr>
<td>Three Cables &amp; Up</td>
<td>40%</td>
</tr>
</tbody>
</table>

9.16 Bus-Duct

9.16.1 The bus bars and connection shall be made of electrolytic grade copper only. Aluminium busbars are not acceptable. All busbars shall be insulated with Raychem sleeving.

9.16.2 It shall be suitably supported at regular intervals and both bus bars and supports shall be adequately sized and clamped to withstand rated short circuit current without permanent deformation.

9.16.3 The bus bar insulators shall be non-hygroscopic, non-inflammable material. Earth bus shall run along the full length of bus duct without any break.
9.16.4 Outdoor bus-duct shall be weatherproof to IP-65 and shall be provided with canopy, silica gel breather. Construction of outdoor Bus duct shall be such that water gets drain off easily. Extra thickness shall be provided at the corners where water accumulation is likely to happen.

9.16.5 Bus duct shall be supplied with bus bar flexible links for connection at both the ends and expansion joints for every 3M of bus-duct and bus duct support materials.

9.16.6 Openings with cover at suitable locations shall be provided on bus duct for accessing the bus bars for maintenance.

9.16.7 Silica-gel breather shall be provided on both indoor and outdoor portions of the busduct. (shall not be required for pressurized busduct).

9.16.8 For all other specifications refer, PC150-TS-0807.

9.17 Load Management System.

9.17.1 Centralised Load Management System (LMS) shall be provided for Supervision, control, monitoring, data acquisition, data logging & printing of status of all important electrical equipment& feeders and Load Shedding Scheme as per the recommendations of the system study report as per process requirement and in consultation with Owner/Consultant for entire fertilizer complex, by EDS LSTK Contractor.

Data concentrator Panel and other LMS System Equipments including PC console, chairs, furniture etc. for Steam Generation Plant shall be in EDS LSTK Contractor’s scope. However, Steam Generation plant LSTK contractor has to consider space for same in separate room in Substations, as per NIT.

LSTK Contractor shall provide multifunctional dual channel transducers in all the breaker feeders as well as contactor feeders of all important & critical Loads. Also, supply & installation of Network Switches and extend all signals up to Network Switches shall be in the scope of Steam Generation plant LSTK Contractor. Network Switch shall have 20 % spare ports. Specification of Network Switches has to be finalised in co-ordination with EDS LSTK Contractor.

Minimum Inputs and Outputs to be considered for LMS for proper operation/control, effective monitoring and load management shall be inclusive of but not limited to the following:

a. Transformers:
   Oil Temperature, Winding temperature, Conservator Oil Level and moisture ppm of Oil through 4-20 mA signal / Modbus communication and status of Buchholz Relay.

b. Incomer /Bus coupler/ Feeder (Power/Motor)
   KW, KVA, KVAR, KWh, PF, VOLTAGE, CURRENT
   ON, OFF, TEST, SERVICE, TRIP ON FAULT, TRIP CIRCUIT HEALTHY, CONTROL SUPPLY ON, RELAY WATCH DOG, FAULT DETAILS, DISTURBANCES RECORDER.
   Remote ON & OFF Control from LMS.

c. LT motor feeder of breaker controlled motors in EPMC/PMCC/MCC
   KW, KVA, KVAR, KWh, PF, VOLTAGE, CURRENT
   ON, OFF, TEST, SERVICE, TRIP ON FAULT, TRIP CIRCUIT HEALTHY, READY TO START, PROCESS TRIP, EMERGENCY STOP, LOCAL/REMOTE selection on LCS, CONTROL SUPPLY ON, RELAY WATCH DOG, FAULT DETAILS, DISTURBANCES RECORDER.
   Remote ON & OFF Control from LMS.

d. LT motor feeder of Contractor controlled motors in EPMC/PMCC/MCC
ON, OFF, TRIP ON FAULT, READY TO START, PROCESS TRIP.

e. Breaker Controlled Power feeder in PCC/MCC/ASPB
KW, KVA, KVAR, KWh, PF, VOLTAGE, CURRENT
ON, OFF, TEST, SERVICE, TRIP ON FAULT, TRIP CIRCUIT HEALTHY, CONTROL SUPPLY ON, RELAY WATCH DOG, FAULT DETAILS, DISTURBANCES RECORDER.
Remote ON & OFF Control from LMS.

f. UPS
Load on Inverter, Load on Bypass, Load on Battery, Battery on float/boost charging mode, Charger failure, Inverter failure, AC mains failure, DC under voltage, DC Over voltage, Automatic retransfer of load to inverter inhibited,
Fan failure, AC Voltage, current & frequency of each inverter, AC incoming power supply Voltage & voltage, DC current at each rectifier output.

Battery & Battery Charger
Status of charging current (float & boost charging), Battery current, Incoming voltage, Load Voltage DC, Load current DC, DC under voltage, DC overvoltage, DC earth leakage, AC incoming power supply failure, AC input fuse blown-off, Thyristor/diode failure, DC output fuse blown-off, DC battery fuse blown-off, Filter Capacitor fuse blown-off, Load on Battery (using current direction sensing with time delay), Battery under voltage/Disconnected during discharge (using zero current sensing), Cubicle fan failure/cubicle temperature high (for chargers with forced cooling).

g. DG Set
KW, KVA, KVAR, KWh, PF, VOLTAGE, CURRENT
ON, OFF, TEST, SERVICE, TRIP ON FAULT, TRIP CIRCUIT HEALTHY, CONTROL SUPPLY ON, RELAY WATCH DOG, FAULT DETAILS, DISTURBANCES RECORDER, Auto/manual switch position status, DG set run hours, Number of starts & number of consecutive starts (ie DG set auto start blocked due to exhaustion of consecutive starts), Day tank diesel level/.

h. VFD
KW, KVA, KVAR, KWh, PF, VOLTAGE, CURRENT, SPEED, SPEED REFERENCE.
ON, OFF, TRIP ON FAULT, TRIP CIRCUIT HEALTHY, FAULT DETAILS
Remote ON & OFF Control from LMS.
All Multi-function Meters of all HT, LT Switchboard, LDB, etc. to be connected with LMS.

9.17.2 All relays and energy meters shall have communication facility for serial communication (Relays on IEC-61850 protocol and Meters on MODBUS protocol).
10.0 CABLING

10.1 Cables

10.1.1 All HV & LV power and control cables for HV/LV switchgear shall be supplied and laid by the contractor. Terminations at switchgear end and at the equipment end shall be in contractor's scope. Supporting and laying of these cables shall also be in contractor's scope. Termination of HV/LV cables at HV/LV motor end and HV switch gear end including supply of heat shrink type termination kit for HV cables shall be in contractor's scope. Supply and execution of heat shrink type straight through jointing kits for HV cables shall be in the scope of the LSTK Contractor (if required).

10.1.2 Cables shall be sized considering the following factors.
   - Maximum continuous load current
   - Voltage drop
   - System voltage
   - Laying conditions
   - De rating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other, thermal resistivity of soil etc. shall be taken into account
   - Short circuit withstand criteria.

10.1.3 All HV power cables shall be made of stranded aluminium conductor with XLPE insulation, PVC inner sheathed FRLS type, armoured, PVC outer sheathed FRLS type, conductor screen, insulation screen and construction as per IS: 7098 (Part 2). HV cables shall be of unearthed type.

Single core HV Power cable shall be of aluminium conductor. The construction of same shall be as per above.

10.1.4 All LV power cables shall be with stranded aluminium/copper conductor with XLPE insulation, PVC inner sheathed FRLS type, armoured, PVC outer sheathed FRLS type and construction as per IS: 7098 (Part 1). Power cables with conductor size upto and including 16 sq. mm shall be with copper conductor, conductor size 35 sq. mm and above shall be aluminium conductor.

Single core LV Power cable shall be of aluminium conductor. The construction of same shall be as per above.

10.1.5 All control cables shall be with 2.5 sq. mm, stranded copper conductor with XLPE insulation, PVC inner sheathed FRLS type, armoured, PVC outer sheathed FRLS type and construction as per IS: 7098 (Part 1). Control cables shall be twisted pair or shielded wherever electro-magnetic/electrostatic interference is anticipated.

10.1.6 All control cables shall have 20% spare cores. All cores shall be identified with numerical core numbers printed on core in addition to colour coding.

10.1.7 All cables shall be armoured and shall have extruded inner and outer sheath.

10.1.8 Cables connected in parallel shall be of the same type, cross section and terminations.

10.1.9 All power and control cables shall be in continuous lengths (except for very long feeders) without any joints. The cables used for lighting and wires in conduits shall have appropriate junction boxes with adequately sized terminals. Cable joints in hazardous areas shall not be permitted.

10.1.10 The maximum voltage drops in various sections of the electrical system shall be within limits stated in the following table:
### Design Philosophy – Electrical

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>System Element</th>
<th>Maximum Permissible Voltage Drop</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>High voltage cables for general distribution</td>
<td>1%</td>
</tr>
<tr>
<td>b)</td>
<td>Bus duct / Cable between transformer secondary and Switchboards</td>
<td>0.5%</td>
</tr>
<tr>
<td>c)</td>
<td>Cable between PMCC and MCC or auxiliary switchboard</td>
<td></td>
</tr>
<tr>
<td>i)</td>
<td>MCC / Auxiliary Switchboard near PMCC</td>
<td>0.5% Note-3b</td>
</tr>
<tr>
<td>ii)</td>
<td>MCC / Auxiliary Switchboard situated remote from PMCC</td>
<td>2 to 2.5% Note-3a</td>
</tr>
<tr>
<td>d)</td>
<td>Cables between HV Switchboard and HV Motor (during running)</td>
<td>3%</td>
</tr>
<tr>
<td>e)</td>
<td>Cable between PMCC and motor (during running)</td>
<td>5%</td>
</tr>
<tr>
<td>f)</td>
<td>Cable between MCC (situated near PMCC) and motors</td>
<td>5%</td>
</tr>
<tr>
<td>g)</td>
<td>Cable between MCC (situated remote from PMCC) and motors</td>
<td>3%</td>
</tr>
<tr>
<td>h)</td>
<td>Cable between Auxiliary Switchboard / MLDB and Lighting Panel / Power Panel</td>
<td>1 to 1.5% (Note-2)</td>
</tr>
<tr>
<td>i)</td>
<td>Circuit between lighting panels and lighting points</td>
<td>4% (Note-2)</td>
</tr>
<tr>
<td>j)</td>
<td>DC Supply Circuit (electrical Controls)</td>
<td>5% and/or as per instrumentation requirement</td>
</tr>
<tr>
<td>k)</td>
<td>DCDB to Control Room</td>
<td>2% (Note-1)</td>
</tr>
<tr>
<td>l)</td>
<td>UPS outgoing circuit</td>
<td>5% (Note-1)</td>
</tr>
</tbody>
</table>

#### Note-1

Minimum voltage available across any instrument in the field / control room / satellite rack room shall be as per instrumentation design basis. Distribution system for instrumentation supplies shall be designed accordingly. In case of any conflict between electrical equipment specification sheet and instrumentation design basis report, the latter shall govern regarding instrumentation power supplies.

#### Note-2

In case of difficulty in achieving specified voltage drops in cables up to lighting panel, 5% drop from Auxiliary Switchboard / MLDB up to lighting points may be permitted.

#### Note-3

a) Higher voltage drop may be permitted between PMCC and remote mounted MCC / ASB; if overall voltage drop up to motor (from PMCC) is limited within 5.5%.

b) For large substations 1% drop may be permitted.

The maximum voltage drop at various buses during start-up of large motor and / or motor reacceleration conditions shall be within the limits stated below:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>System Element</th>
<th>Operating Condition</th>
<th>Maximum Permissible</th>
</tr>
</thead>
</table>
Voltage Drop

a) At the bus bars of the worst affected Switchboard
Start-up of the large HV motor with other loads on the bus or reacceleration of a group of HV motors (Simultaneous start-up or group reacceleration of HV motors is not envisaged) 10%

b) At the bus bars of the worst affected MV Switchboard (PMCC / MCC)
Start-up of large MV motor with other loads on the bus, or reacceleration of a group of MV motors. 10%

c) Cables between HV Switchboard and motor
Motor start-up or reacceleration 5% (Note-a)

d) Cable between MV Switchboard (PMCC / MCC) and motor
Motor start-up or reacceleration 10% (Note-a)

Notes:

a) Higher voltage drop in motor cables may be permitted, in case the conditions given in Note b), c) and d) are complied.

b) The voltage available at the motor terminals during start-up must be sufficient to ensure positive starting or reacceleration of the motor (even with the motor fully loaded, if required), without causing any damage to the motor.

c) For medium voltage motors, the voltage available at the motor terminals must not be less than 80% of the rated value during start-up or reacceleration.

d) For high voltage motors, the voltage available at the motor terminals must not be less than 85% of the rated value during start-up or reacceleration.

e) Soft Starter / VFD Starter shall be considered for starting large HV motors if essential / unavoidable as per system design requirement / equipment design limitation. For cases other than starting limitation, requirement of soft starter / VFD for any drive shall be confirmed by Process Department.

f) Unless otherwise specified as in clause e), all HV motors and MV motors shall be suitable for Direct on Line (DOL) starting.

10.1.11 MINIMUM CABLE SIZES FOR 415V MOTORS
Direct on line (D.O.L) start motors (2/4 pole motors)

<table>
<thead>
<tr>
<th>MOTOR RATING</th>
<th>CABLE DETAILS</th>
<th>NO. OF CORES PER RUN</th>
<th>CONDUCTOR MATERIAL</th>
<th>CONDUCTOR SIZE (MM²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 3.7 KW</td>
<td>1 3 Cu</td>
<td>Cu</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>3.7 KW</td>
<td>1 3 Cu</td>
<td>Cu</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5.5 KW</td>
<td>1 3 Cu</td>
<td>Cu</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>7.5 KW</td>
<td>1 3 Cu</td>
<td>Cu</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>9.3 KW</td>
<td>1 3 Cu</td>
<td>Cu</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>11 KW</td>
<td>1 3 Cu</td>
<td>Cu</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>15 KW</td>
<td>1 3 Cu</td>
<td>Cu</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>18.5KW</td>
<td>1 3 Al</td>
<td>Al</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>22 KW</td>
<td>1 3 Al</td>
<td>Al</td>
<td>35</td>
<td></td>
</tr>
</tbody>
</table>
Cables sizes as indicated above are for 2/4 poles motors fed from MCCs located near PCCs and PMCCs.

Cable sizes for motors not confirming to above table (e.g. for 2/4 poles motors rated up to 150kw & motors with high starting pf), extended distance, reduced voltage starting, low speed motors, VFD driven etc. shall be worked out on case to case basis.

However cable sizing calculation shall be submitted for approval.

10.1.12 Design Criteria for Cables/Bus Duct & Short Circuit Withstand Time:

a) Design criteria for cables/bus duct

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Design Criteria</th>
<th>3.3 kV / 11 kV</th>
<th>415 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Loads beyond 1000A rating and located near the transformer</td>
<td>Bus Duct / 1-core cable</td>
<td>Bus Duct / 1-core cable</td>
</tr>
<tr>
<td>2.</td>
<td>Loads located up to 200 M</td>
<td>Cable</td>
<td>Cable</td>
</tr>
<tr>
<td>3.</td>
<td>Loads located 200 - 1000 M</td>
<td>1-core cable / 3-core cable</td>
<td>1-core cable / 3.5-core cable</td>
</tr>
<tr>
<td>4.</td>
<td>Loads located beyond 1 KM</td>
<td>Cable</td>
<td>Cable</td>
</tr>
<tr>
<td>5.</td>
<td>Recommended limiting size of multi-core cable (sq.mm) / Single Core (sqmm)</td>
<td>3 Core x 400 / 1 Core x 630</td>
<td>3.5 Core x 300 / 1 Core x 630</td>
</tr>
<tr>
<td>6.</td>
<td>Insulation voltage grade</td>
<td>3.3 kV / 11 kV Unearthed</td>
<td>1100 V Earthed</td>
</tr>
<tr>
<td>7.</td>
<td>Type of cable insulation</td>
<td>XLPE</td>
<td>Power: XLPE Control: XLPE</td>
</tr>
<tr>
<td>8.</td>
<td>Power, Control &amp; Earthing Cables</td>
<td>Armoured</td>
<td>Armoured</td>
</tr>
</tbody>
</table>

For breaker control motor circuits the selection of size will be made ensuring that the cable shall withstand a short circuit fault directly for 0.2 sec. Suitable derating factors based on the site ambient conditions, method of laying and the no. of cables laid together shall also be applied.

b) Short circuit withstand time (seconds) shall be as follows for Breaker controlled feeders.

- Bus duct: 1 Sec.
- Feeder to motors and transformer: 0.25 sec
- Feeder from PCC/PMCC to MCC: 0.6 sec
- Main 11 KV primary distribution feeders: 0.7 sec
- 11 KV cable from generator & transformer to switch board: 1 sec
- Incomer from other switchboard: 0.6 sec

10.1.13 The minimum size of power cables shall be 2.5 sq. mm (Cu).
10.1.14 The control cables shall be 2.5 sq. mm (Cu). However, wiring in the panel/switch boards may be by means of 1.5 sq. mm (Cu) cables except for CT wiring which shall be 2.5 sq. mm. All the control and power wiring shall be carried by using FRLS wires only.

10.1.15 For all other specifications, refer PC150-TS-0815.

10.2 Cable Laying

10.2.1 The cables shall generally be laid on overhead racks. Pipe racks where available, shall be used to support the cable racks.

HV power cable shall be laid on cable tray in single layer having 1D spacing between the cables. LV power and control cable shall be laid on cable tray in touching formation in single layer.

HV Power, LV Power and Control shall be on separate trays. Instrument and electrical cable trays shall be separate.

Cables shall be clamped properly on the cable rack in such a way that position and layout of a particular cable shall not change throughout the rack so that it can be easily traced during maintenance jobs.

Walkway to be considered for access to Electrical / Instrument cables on pipe rack.

From substations to various electrical consumers, cable shall be laid overhead. However, wherever overhead cable routing is not feasible LSTK Contractor can go for cable trench / slit (Refer PDS attached with the NIT) as per the site requirement.

Wherever, pipe rack is not available and space for overhead cable laying is possible then dedicated structure for cable shall be made for cable laying.

10.2.2 The cable racks shall be ladder type, pre-fabricated from suitable hot dip galvanised steel/heavy duty FRP material. Cable racks around cooling tower areas shall be of heavy duty FRP (fire retardant and UV stabilized) material. Maximum cable tray size shall be 600mm wide. Maximum supporting span shall be 2 Mtrs. as per PDS Doc. No. PDS: E 530 attached with the NIT. Cable trays shall be designed considering 25% margin for future use.

All cable racks must be provided with GI flat strip of size 75mm X12 mm as running earth all along the tray.

10.2.3 FRP Cable Tray shall be as per NEMA FGI-198X. FRP Cable Tray shall be UV exposed as per ASTM G 154 fro 1000 Hrs and the mechanical properties shall not be deteriorate more than 5%. Glass content shall be greater than 55%. The run spacing shall be 250m.

10.2.4 All cables shall be terminated using suitable cable lugs.

10.2.5 All HV terminations and joints shall be of RAYCHEM make only.

10.2.6 Bimetallic lugs shall be provided, as required.

10.2.7 In Control Room (excluding false ceiling) and Substation, lighting cable shall be laid in concealed conduit.

10.2.8 For all other specification of cable racks, refer PC150-TS-0816 & PDS attached.

11.0 ILLUMINATION SYSTEM

11.1 General

11.1.1 LED type lighting shall be provided. The average illumination levels in the various sections of the plants shall be as indicated in Annexure-I. All the plants and area lighting shall be energy efficient.

11.1.2 LED type lighting shall be provided for all areas. The minimum illumination levels in the various sections of the plants shall be as indicated in Annexure-I.

LED shall conform to the following types and standards:-
Maintenance factor for indoor lighting shall be considered as 0.7 and for Outdoor lighting 0.6.

The colour rendering index shall not be less than 90%.

The LED lights shall work satisfactorily at the design temperature of 50 Degree Celsius.

All the LED fittings shall be selected in accordance with Hazardous Area Classification.

The life assessment of LEDs shall include control gears/driver as well.

11.1.3 The specified illumination level shall be maintained after considering maintenance factor 0.5 for Coal Dust Area, 0.6 for plant & outdoor areas (other than Coal Dust Area) & 0.7 for indoor areas and utilisation factor as per manufacturer catalogues for size of room & type of fixture.

11.1.4 Separate area wise panic lights, fed from 110 V DCDB shall be provided at strategic locations for safe evacuation of operation personnel. These shall be switched ‘ON’ automatically on failure of power supply to main lighting board and shall switch ‘OFF’ automatically on resumption of mains or after 1 hour of power failure to avoid draining of the battery. Location of these lights shall be judiciously decided from safety considerations. The outdoor lighting shall be photocell/timer controlled.

11.1.5 Voltage drop at the fixture from the MLDB bus shall not exceed 3%.

11.1.6 Aviation lights shall be provided on tall structures and all isolated structures. Aviation Lighting shall be in accordance with International Civil Aviation Organization (ICAO) Publication Annexure 14 and to Indian Standards, together with the approval of local aviation authority.

LED type Low Intensity Aviation Obstruction Light suitable for 240V, 50 Hz supply. It shall be covered under Indian patent act (Govt of India) No. 188995. Degree of protection shall be IP-65.

The illumination intensity of aviation lights and mounting height shall be considered based on vicinity of civilian air terminal within 1 km radius. Aviation lights at each location shall be fed from two separate and distinct DBs (one fed from normal bus and another fed from emergency bus of MLDB). Incase aviation lights are not switched ON for any reason, whatsoever, a signal shall be sent to control room which will sound buzzer and also result in flashing of red light. On acknowledgement, buzzer shall stop but flasher will continue unless aviation lights are turned ON.

The fixtures shall have body of corrosion resistant aluminium alloy casting and shall be suitable for outdoor use and mounting on 40 mm NB G.I. pipe. Necessary electrical threading shall be tapped in the fixture for mounting.

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Safety Standard</th>
<th>Performance Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self ballasted LED lamps for general lighting services &gt; 50 V</td>
<td>IEC 62560 Latest Edition</td>
<td>IEC 62612 / PAS Publicly available specification</td>
</tr>
<tr>
<td>LEDs and LED modules</td>
<td>IEC TS 62504 Terms and modules in general lighting.</td>
<td>Definitions for LEDs and LED</td>
</tr>
</tbody>
</table>
11.1.7 Plant lighting circuits shall be single phase (Phase & Neutral) rated 240 V AC. Each circuit shall be rated to 16A but not loaded more than 8A. A minimum of 25% of MCBs of each board shall be left as spares. The load on one lighting sub-circuit of lighting sub-distribution board and junction box shall be limited to 1000W approx.

11.1.8 The lighting sub-distribution board for control of lighting shall be standardized as 18-way, 15-way, 12-way, 9-way and 6-way type.

11.1.9 In plant office rooms, wall mounting boards shall be installed to control the lighting. These boards shall include switches for lights, fans, 15A/5A plug sockets and fan regulators etc.

11.1.10 15A plug sockets shall be fed through separate circuit of lighting sub-distribution boards/junction box having ELCB of 30mA.

11.1.11 16A plug sockets shall be fed through separate circuit of lighting sub-distribution boards/junction box.

11.1.12 Illuminated exit sign shall be provided in substation / Control Room.

11.1.13 Power factor of complete fitting shall be 0.95 min. at 230 V.

11.1.14 Lights from LED’s shall be soothing to eye and without any bright spots on the floor/objects illuminated by the luminaries.

11.1.15 The driver shall be mounted internally and be replaceable with the aid of commonly available hand tools.

11.1.16 The LED module or array shall be designed in such a way that the failure of one LED shall not affect additional LED’s.

11.1.17 Life expectancy of LED Luminaries shall be minimum of 50000 hrs with greater than 70% of rated lumen output.

11.1.18 Min. efficiency of LED driver: The minimum efficiency of LED driver shall be 85% for driver power output rating <=40W and 87% for driver power output rating> 40W.

11.1.19 Short circuit protection /Open load protection shall be required for LED fixtures.

11.1.20 Surge Protection for minimum 2kV for indoor and minimum 3kV for Outdoor LED systems shall be provided. However, If a site is prone to lightning and surges 10kV surge protection shall be required. In case of outdoor luminaires, the Surge Protection Device (SPD) should be series type with fail safe.

11.1.21 Color temperature of LED Luminaries: 5700K

11.1.22 Cover type for outdoor type fittings shall be Toughened glass or UV stabilized polycarbonate whereas, for indoor and non-weather proof items, UV stabilized Poly Carbonate can be used.

11.1.23 For more details, refer PDS attached.

11.1.24 For lighting fixtures and 16 Amp plug socket circuits, 3 core 2.5 sq. mm (Cu) cable shall be used.

11.2 LED Tube Lighting Fixtures (inside Substations)

a) High quality LED fluorescent tube twin batten type complete with 2 X 20W tube eco friendly, no UV radiation as per the specification tabulated below:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Parameter</th>
<th>Technical Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Degree of Protection</td>
<td>IP-20</td>
</tr>
<tr>
<td>2.</td>
<td>Lumen output per Lamp</td>
<td>≥ 2000</td>
</tr>
<tr>
<td>3.</td>
<td>CCT</td>
<td>6500K</td>
</tr>
<tr>
<td>4.</td>
<td>Luminous efficacy</td>
<td>≥ 100 lm/watt</td>
</tr>
<tr>
<td>5.</td>
<td>CRI</td>
<td>&gt;80</td>
</tr>
<tr>
<td>6.</td>
<td>Guaranteed Life</td>
<td>≥ 50000 burning hours</td>
</tr>
</tbody>
</table>
11.3 Street Lighting And Security Lighting

11.3.1 63A TPN outlet from outdoor lighting bus of main lighting board shall be taken direct to the TPN junction box to be mounted on pole through cable and looped from pole to pole.

11.3.2 Hot dip GI octagonal poles of suitable mounting height shall be used for street light. However, for plant lighting (platforms/ structures/ access ways/ walk ways/ pump house/ pump bay etc.), steel tubular poles of suitable mounting height shall be used. The poles shall be subjected to min. following tests:
- Thickness of galvanising
- Drop test as per IS: 2713.
- Deflection test as per IS: 2713

11.3.3 Hot dip galvanized octagonal high mast lighting shall be used for yard and general area lighting. LED type fittings may be used.

11.3.4 LED Street Lighting Fixtures

a) LED Street Light Fitting with cool white light in Pressure Die Cast Aluminium Housing with UV Stabilized Poly Carbonate Cover with in-built power unit of 3500 lumen suitable for 240V, 50 Hz, System shall be used.

b) Lighting fixture shall have 50000 hrs. Life Time, CRI>75, IP-65.

11.3.5 High Mast

In Coal Handling Area and other open area, High Masts shall be provided.

a) Structure

The High mast shall be of continuously tapered, polygonal cross section, at least 16 sided, presenting a good and pleasing appearance and shall be based on proven In-tension design conforming to the standards referred, to give an assured performance, and reliable service.

The mast height shall be 30m, with minimum diameter of 150mm at the top and 610mm at the bottom. Minimum plate thickness of bottom section shall be 5mm and other sections 4mm. The structure shall be suitable for wind loading as per IS 875 Part III, 1987 & for 9 Nos. 2x200W & 3 Nos. 1x200W LED flood light fittings. The PCD of the mast flange shall be minimum 740mm.

b) Construction

The mast shall be capable of safely withstanding the strong winds prevailing at site. The deflection at the top during heavy monsoon periods shall therefore be considered in the design and the mast designed in such way that the above deflection during worst periods is kept to a minimum value.

The High mast shall be fabricated from special steel plates, conforming to BS-EN10025, cut and folded to form a polygonal section and shall be telescopically jointed and fillet welded. The welding shall be in accordance with BS: 5135. The procedural weld geometry and the workmanship shall be exhaustively tested on the completed welds. Mast shall be delivered in multiple sections of length approx.10 metres. Thus a 30 meter mast shall be delivered in three sections.

Each mast section, delivered to site, shall include one no. circumferential welded diaphragm stiffener to reduce the deflection of the mast in heavy winds. At site, the sections shall be joined together by slip-stressed-fit method. No site welding or bolted joint
shall be done on the mast. The minimum overlap distance shall be 1.5 times the diameter at penetration.

The mast shall be provided with full penetrated flange which shall be free from any lamination or incursion. The welded connection of the base flange shall be fully developed to the strength of the entire section. The base flange shall be provided with supplementary gussets between the bolt holes to ensure elimination of helical stress concentration. For the environmental protection of the mast, the entire fabricated system shall be hot dip galvanised, internally and externally, having a uniform thickness of 65 microns for the bottom and top sections.

c) Door Opening
An adequate door opening of size 1000mm x 300mm shall be provided at the base of the mast and the opening shall be such that it permits clear access to equipment like winches, cables, plug and socket, etc. and also facilitate easy removal of the winch. The door opening shall be complete with a close fitting, vandal resistant, weather proof door, provided with a heavy duty double internal lock with special paddle key.

The door opening shall be carefully designed and reinforced with welded steel section, so that mast section at the base shall be unaffected and undue buckling of the cut portion is prevented.

d) Dynamic Loading for the Mast
The mast structure shall be suitable to sustain an assumed reaction arising from a wind speed as per IS: 875 (three second gust), and shall be measured at height of 10m above ground level. The design life of the mast shall be a minimum of 25 years. Wind excited oscillations shall be dampened by the method of construction and adequate allowance shall be made for the related stresses.

e) Earthing Terminals
3 Nos. earthing terminals, one for lightning protection and other two for electrical earthing of the mast, using 12 mm dia. stainless steel bolts shall be provided at convenient location on the base of the mast.

f) Lantern Carriage
i) Fabrication
A fabricated Lantern Carriage shall be provided for fixing and holding the flood light fittings and control gear boxes. The Lantern Carriage shall be of special design and shall be of steel tube construction, the tubes acting as conduits for wires, with holes fully protected by grommets. The Lantern Carriage shall be so designed and fabricated to hold the required number of flood light fittings and the control gear boxes, and also have a perfect self balance.

The Lantern Carriage shall be fabricated in two halves and joined by bolted flanges with stainless steel bolts and plastic lock type stainless steel nuts to enable easy installation or removal from the erected mast. The inner lining of the carriage shall be provided with protective PVC arrangement, so that no damage is caused to the surface of the mast during raising and lowering operation of the carriage. The entire Lantern Carriage shall be hot dip galvanised after fabrication.

ii) Junction Box
Weather proof junction box with IP65 enclosure, made of cast Aluminium shall be provided on the Carriage assembly as required, from which the inter-connections to the designed number of the flood light luminaries and associated control gears fixed on the carriage, shall be made.

g) Raising and lowering mechanism
For the installation and maintenance of the luminaries and lamps, it will be necessary to lower and raise the Lantern Carriage assembly. To enable this, a suitable winch arrangement shall be provided, with the winch fixed at the base of the mast and the specially designed head frame assembly at the top.

i) Winch

The winch shall be of completely self sustaining type, without the need for brake shoe, springs or clutches. Each driving spindle of the winch shall be positively locked when not in use, gravity activated PAWLS. Individual drum also should be operated for fine adjustment of lantern carriage. The capacity, operating speed, safe working load of the winch and the recommended lubrication and serial number of the winch shall be clearly marked on each winch.

The gear ratio may be according to manufacturer’s standard. However, the minimum working load shall not be less than 750Kg. The winch shall be self lubricating type by means of an oil bath and the oil shall be readily available grades of reputed producers.

The winch drums shall be grooved to ensure perfect seat for stable and tidy rope lay, with no chances of rope slippage. The rope termination in the winch shall be such that distortion or twisting is eliminated and at least 5 to 6 turns of rope remains on the drum even when the lantern is fully lowered and rested on the rest pads.

It should be possible to operate the winch manually by a suitable handle and / or by an external power tool. It shall be possible to remove the double drum after dismantling, through the door opening provided at the base of the mast.

Also, a winch gear box for simultaneous and reversible operation of the double drum winch shall be provided as part of the contract. A test certificate shall be furnished by the Bidder from the original equipment manufacturer, for each winch in support of the maximum load operated by the winch.

ii) Head Frame

The head frame, which is to be designed as a capping unit of the mast, shall be of welded steel construction, galvanised both internally and externally after assembly.

The top pulley shall be of appropriate diameter, large enough to accommodate the stainless steel wire ropes and the multicore electric cable. The pulley block shall be made of non-corrodible material, and shall be of die cast Aluminium alloy (LM-6). Pulley made of synthetic materials such as plastic or PVC is not acceptable. Self lubricating bearings and stainless steel shaft shall be provided to facilitate smooth and maintenance free operation for a long period. The pulley assembly shall be fully protected by a canopy galvanised internally and externally.

Close fitting guides and sleeves shall be provided to ensure that the ropes and cables do not get dislodged from their respective positions in the grooves. The head frame shall be provided with guides and stops with PVC buffer for docking the lantern carriage.

iii) Stainless Steel Wire Ropes

The suspension system shall essentially be without any intermediate joint and shall consist of only non-corrodible stainless steel of AISI 316 or better grade. The stainless steel wire ropes shall be of 7/19 construction, the central core being of the same material. The overall diameter of the rope shall not be less than 6mm. The breaking load of each rope shall not be less than 2350Kg individually, giving a factor of safety of over 5 for the system at full load as per the TR-7 referred to in the beginning of this specification. The end constructions of ropes to the winch drum shall be fitted with telluric.

The thimbles shall be secured on ropes by compression splices. Two continuous lengths of stainless steel wire ropes shall be used in the system and no intermediate joints are acceptable in view of the required safety. No intermediate joint either bolted or else is provided on the wire ropes between winch and lantern carriage.
h) Electrical System, cable and Cable Connections

The electrical connection from bottom to top shall be made with at least 5 core 2.5 sq. mm flexible round sheath power cables using copper conductors of appropriate rating. A suitable flameproof socket arrangement shall be provided at the bottom of the mast. The trailing cable shall also have an FLP plug connected at the bottom end. Also, suitable provision shall be made at the base compartment of the mast to facilitate the operation of externally mounted, electrically operated FLP power tool for raising and lowering of the lantern carriage assembly. The trailing cables at the top shall be terminated in the weather proof junction box.

i) Power Tool for the Winch

A suitable, high powered, electrically driven, flameproof, integral mounted power tool, with manual handle together with an operating stand shall be supplied for the raising and lowering of the lantern carriage for maintenance purposes. The speed of the power tool may, preferably, be slow of 1.5 to 1.8 metre/minute, so that vibrations associated with high speed operation are avoided. The power tool shall be single speed, provided with a flameproof motor of required rating, suitable for trolley mounting. The power tool shall be supplied with suitable reversible starter in flameproof enclosure. The capacity and speed of the electric motor used in the power tool shall be suitable for the lifting of the design load installed on the lantern carriage. The power tool trolley shall be so designed that it will not only be self supporting but also aligns the power tool perfectly with respect to the winch spindle during the operations. Also, a handle for the manual operation of the winch in case of problems with electrically operated tool, shall be provided and shall incorporate a torque limiter.

j) Lightning Finial

One number heavy duty, hot dip galvanised, lightning finial shall be provided for each mast. The lightning finial shall be minimum 1.2m in length and shall be provided at the centre of the head frame. It shall be bolted solidly to the head frame to get a direct conducting path to the earth through the mast body. The lightning finial shall not be provided on the lantern carriage under any circumstances in view of safety of the system.

k) Luminaries

i) Each mast shall be fitted with required numbers of specially designed non integral type high mast luminaries (IP-65) complete with separate control gear box (IP-65) suitable for 200W LED lamps. Two types of fittings shall be used, viz. 2X200 W LED (asymmetrical) and 1X200W LED (symmetrical).

ii) Twin dome LED type (2x40W) Aviation Obstruction Lights of reliable design and reputed manufacturer shall be provided on top of each mast. It shall have cast aluminium housing finished in aviation yellow colour, suitable rated step-up transformer, thick glass dome mounted on cast aluminium ring and spring loaded high tension porcelain socket fitted with neon cold cathode helix light source. The light source shall be designed to give Omni-directional red colour light distribution to have maximum light output in the zone between 10°C to 90°C above horizontal plane.

11.3.6 24 V Portable Module

The 24V A.C. supply modules (with air-cooled two winding, 500VA, 1-phase, 50HZ, 240/24V transformer with HRC fuses on both primary & secondary side and necessary 240V and 24V terminals for incoming and outgoing connections ) shall be sheet steel enclosed with louvers and shall be suitable for outdoor use. The 240V terminals of 24V AC supply module shall be fed from respective lighting panels / 5/15A Switch socket.

240 V AC Terminal shall be 20 Mtr PVC insulated PVC sheathed cables and 5/15 A Plug Top.

24 V Output shall be complete with 50 Mtr PVC insulated PVC sheathed cables, 24 V 20 W LED hand lamps with suitable hook.
12.0 EARTHING AND LIGHTNING PROTECTION

12.1 Earthing

12.1.1 Complete earthing installation shall be done as per IS: 3043, IEEE-80, IE Rules and IEC recommendations. The earthing system shall be designed to:

(a) Provide a permanent & continuous path from equipment and conductor enclosures to earth from circuits for flow of fault current.

(b) Provide sufficient current carrying capacity to conduct safely any current liable to be imposed on it.

(c) Provide sufficient low resistance to earth to limit the potential between metalwork and earth within safe limits.

(d) Provide equal distribution of potential and minimum potential difference for safety of personnel.

(e) Ensure sufficient current in case of fault to facilitate the operation of relays, over current devices, fuses etc. provided in the circuit.

12.1.2 Common underground earthing grid shall be provided covering sub-stations and plants which is further connected to overall Earthing Grid. The overall earth resistance (dry) shall be limited to 1 ohm.

12.1.3 Earthing rings shall be provided around sub-stations and plants which in turn shall be connected to the common earthing grid. Minimum size of main grid shall be 75mm×12mm. Anti-corrosive bituminous paint shall be provided at each joint of earth flat after necessary finishing and priming treatment .

12.1.4 Earthing grid/ring shall comprise of buried GI earth strips and GI pipes/electrodes.

12.1.5 Separate earth electrodes shall be provided for system neutral earthing. For equipment earthing, minimum two numbers of electrodes shall be provided around each plant/section. However, all these earth electrodes shall be interconnected.

12.1.6 Inter-connecting pits having an earth bus in an enclosed brick chamber without earth electrode shall be provided in the common underground earthing grid for convenience of taking earth conductors inside the plants.

12.1.7 As far as possible, the reinforcement rods inside concrete column shall be connected to the earthing grid/ring to reduce the overall earth resistance.

12.1.8 Individual electrical equipment shall be earthed by GI strip/GI wire/Cu/Al cable. Earth buses shall be provided in plants for earthing groups of electrical/non-electrical equipment to earthing grid/rings.

12.1.9 Size of earthing grid/ring and earth conductors of equipment for generating station and sub-stations shall be as per relevant standards. The fault current magnitude shall be decided based on system fault level. The time duration shall be taken as 1 second for voltage level above 66 kV and 3 seconds for voltage upto 66 kV as per IS -3043.

12.1.10 All equipment rated above 250 V shall have two external earth connections and those rated up to 250 V shall have one external earth connection. However, for lighting fixtures, earthing shall be done through 3rd core of the cable in safe as well as in hazardous area.

12.1.11 Flameproof equipment, in addition, shall have one internal earth connection. This means that 4 core cables to be used for all the flameproof equipments and 3.5 core cables to be used for all flameproof motors located at hazardous area.

12.1.12 All steel structures, tanks, vessels, pipes, pipe joints, valves etc. shall be earthed against static charge accumulation by 50x6 mm GI strip. The no. of earth connections shall be as follows:

<table>
<thead>
<tr>
<th>Equipment having diameter</th>
<th>Hazardous area</th>
<th>Non hazardous area</th>
</tr>
</thead>
</table>
12.1.13 Wherever process equipments are mounted on steel structures, the structures shall be earthed instead of earthing the individual equipment.

12.1.14 The pipe structures shall be earthed at not more than 25M apart.

12.1.15 For all equipment in hazardous area, in addition to external earthing one internal earthing shall be provided.

12.1.16 Minimum sizes of earth conductors to be used shall be as given below.

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Equipment</th>
<th>GI conductor size</th>
<th>Al conductor Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>HV/LV switch board, transformers, HV motors</td>
<td>50mm×8mm</td>
<td>150 sq. mm</td>
</tr>
<tr>
<td>2.</td>
<td>Motors rated 75 KW and above</td>
<td>50mm×6mm</td>
<td>150 sq. mm</td>
</tr>
<tr>
<td>3.</td>
<td>Motors rated 30 KW to less than 75 KW and vessel earthing</td>
<td>35mm×6mm</td>
<td>95 sq. mm</td>
</tr>
<tr>
<td>4.</td>
<td>Motors rated 5.5 KW to less than 30 KW</td>
<td>25mm×6mm</td>
<td>25 sq. mm</td>
</tr>
<tr>
<td>5.</td>
<td>Motors less than 5.5 KW</td>
<td>8 SWG</td>
<td>6 sq. mm</td>
</tr>
<tr>
<td>6.</td>
<td>All minor equipment rated 250V &amp; above.</td>
<td>10 SWG</td>
<td>6 sq. mm</td>
</tr>
<tr>
<td>7.</td>
<td>Earth Grid</td>
<td>75mm x 12 mm.</td>
<td>-</td>
</tr>
</tbody>
</table>

Vendor to calculate the actual size. However, higher size of calculated one or above-mentioned size shall be provided.

All GI conductors shall meet the galvanizing requirement as per IS.

12.1.17 The main ground grid shall be buried in earth at a minimum depth of 1000 mm below finished grade level unless stated otherwise

12.2 Lightning Protection

12.2.1 All structure shall be protected against lightning strokes by suitable lightning protection system to be designed and installed as per IS/IEC-62305.

12.2.2 The number of down conductors shall be minimum two.

12.2.3 Bare metallic structures shall not have any air termination rods at the top. The earth connections shall be welded to the bottom of structure at 300 mm above floor level. However, tall metallic columns with insulation at top shall be provided with air termination rods. Separate earth electrodes shall be provided for each down conductor of lightning protection. However, these shall be inter-connected with the other electrodes in main grid.

12.2.4 Air Terminal

The vertical air terminal rods shall be installed at the roof of buildings (including power house main building), at the top of chimney and cooling towers to protect these objects from lightning strokes.

The vertical air terminal except for chimney shall be made of 20 mm dia galvanized steel rod. The projected length of the rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.

The air terminal rods provided at the top of chimney/stack for lightning protection shall be 20 mm dia lead coated solid copper rod.

The air terminal rod shall be properly fixed on the top of the building/structure to withstand very high wind pressure. In case the air terminal rod is embedded at the top of roof of
building: the portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.

All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size 50 x 6 mm galvanized steel flats.

The shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 degrees.

Horizontal air termination (i.e. G.S. Flat conductor) shall be so laid that no part of the roof will be more than nine (9) metres from the nearest roof conductor.

12.2.5 Shielding Masts

The shielding mast for lightning protection shall be installed at the top of steel columns cap plates of power house main building.

The shielding mast shall be made of galvanized steel pipe and the height of the same shall be decided considering the zones to be protected.

Each shielding mast shall be connected to grounding grid by a down conductor 50 x 6 mm. Galvanized steel flat run along the building column. In addition all power house building columns joints shall be electrically bonded.

12.2.6 Down Conductors

The down conductors shall be 50 x 6 mm galvanized steel flats. The connection between each down conductor and earth electrode shall be made via test link located at approximately 1500 mm above ground level.

13.0 CATHODIC PROTECTION SYSTEM

13.1 Entire underground pipe work including those laid in concrete trench and filled with sand, the steel structures (within battery limit), tank bottom etc. shall be provided with cathodic protection in their battery limit. The scope shall include, site surveying to collect required information, design, supply, installation, commissioning, maintenance, monitoring and performance guarantee of impressed current cathodic protection system as per relevant Indian/IEC/BS/NACE Standards and codes of practices. Contractor shall have to design and engineering of complete CP system for their battery limit. The design life of CP System shall be 30 years.

Following shall be excluded from Cathodic Protection system.

- Underground Pipes with SS material / GRP Material,
- Above Ground reinforcements bars of reinforced concrete,
- Reinforcements bars of reinforced concrete foundations.
- Reinforcement bars in concrete piles.

13.2 LSTK Contractor shall carryout the detail site survey to confirm the desired limits of polarized potential as per standard, functionality check, vetting / confirmation of the system by NACE -4 Level certified person having more than 3 years’ experience in the plant structure CP WORKS.

13.3 The SCOPE shall include but not limited to the CP system consisting of TR Units, Various types of anode beds, associated system and for monitoring the parameters SCADA System is provided.

13.4 There shall be centralised SCADA system to control and monitor the CP system of the complete plant. CP system of individual unit shall have the provision for hook-up with centralised CP SCADA system.

13.5 Shed shall be provided for all Cathodic Protection equipment installed in the field.

13.6 Solid State Polarization Cell shall have short time fault current withstand capacity:- 5 kA/ 5000 A @ 30 Cycles and Lightening Surge Current rating : 50000 A Crest for 8 to 20 μ seconds with DC Blocking voltage range of - 3.0 V to + 1.0 V.
13.7 Surge over voltage diverter shall be provided across each monolithic isolation joint.

13.8 For all other specifications, refer PC150-TS-0823, PC150-TS-0824, PC150-TS-0825.

14.0 CAPACITOR BANKS

14.1 The LSTK Contractor shall ensure that the power factor remains minimum 0.95 lag (inductive) in all the Bus of HV, MV& LV Switchboards.

Suitable capacitor bank shall be designed and installed at 415 V voltage level in the substation.

Capacitor bank at 3.3 kV or 11 kV may also be considered, if required.

The capacitor bank shall utilize the Automatic Power Factor Controllers to maintain the power factor of individual plant. Under no circumstances power factor shall become leading (capacitive) and all necessary protections to avoid this shall be used.

14.2 For all other specifications, refer PC150-TS-0822.

15.0 COMMUNICATION SYSTEM (PA & Paging System)

15.1 Public Address system suitable to provide reliable and quick source of communication among operating personnel shall be provided. The system shall be microprocessor based with modular construction for ease of expansion capabilities and capacity. The system shall have speakers, calling points etc. suitable to area of classification for that location.

Substation shall be connected with the PA System.

PA system shall be located in respective control room.

Minimum no. of field call stations of PA System shall be 15 Nos.

Minimum No. of PA Speakers shall be 15 Nos.

1 Nos. Master Call Station shall be considered and to be install at control room. Additionally Call Station shall also be provided in Substation.

All required furniture, PC console with chairs for complete PA System shall be in scope of LSTK Contractor.

15.2 Close talk mode shall be provided for conversation between two or more stations through close talk channel. Speeches from any hand set shall be heard over all the speakers. The system shall have the following facility:-

i) Alert tone facility

ii) Paging facility

iii) Private conversation facility

iv) Loud speaker mute facility

i) Emergency tone facility.

15.3 The system may be centrally located at a particular plant but the location shall in no way affect the performance of system. If required separate but interconnected system shall be provided. The microphone system shall be capable to suppress the environmental noise which will be present in the plant due to machineries.

15.4 It shall be possible to have automatic testing, monitoring, fault diagnosis etc. through interface PC. The system programming shall be user friendly through interface PC.

15.5 Separate dedicated UPS with battery back-up of 8 hours shall be considered for PA System. VRLA type maintenance free Ni-Cd Battery shall be provided.

15.6 Paging speakers provided in areas having ambient noise levels shall produce a paging sound level at least 10 dB above the anticipated ambient noise level. Where it is not possible to achieve the sound level of above 10 dB above the ambient, rotating beacons shall be
15.7 The design of the system shall be such as to provide two channel communication i.e. Page & Party in each zone. Page & Party system shall comprise of one channel for paging & one channel for party talk.

15.8 It shall be possible to communicate between two field stations without the interference of the MCS / operator. Also it shall be possible to have direct communication with the MCS.

15.9 The equipment shall be sturdy, impact resistant, dust & damp proof generally conforming to minimum IP 66 degree of protection. For classified hazardous areas flameproof equipment shall be provided duly certified by recognised certifying authority for the area of installation.

15.10 Acoustic hood for PA stations in Steam Generation Plant in addition with acoustic hood in noisy area shall be considered.

15.11 Paging system shall be interfaced with EPABX and Fire Alarm System.

15.12 Each PA System shall have 20% spare capacity.

15.13 10 nos. flameproof walkie-talkie alongwith Base Station & License and 10 nos. flameproof hand lamps shall be provided for convenience of installation, operation and maintenance of equipment.

15.14 Separate Centralised PA System of entire fertiliser complex shall be provided by EDS LSTK Contractor. However hook-up of PA System of Steam Generation Plant with Centralised PA System shall be in LSTK Contractor’s scope. All interfacing equipment as well as cabling required for hook-up shall be in LSTK Contractor’s scope.

15.15 All cables (including communication cable) shall be armoured type only.

15.16 For all other specifications refer PC150-TS-0801.

16.0 FIRE DETECTION AND ALARM SYSTEM

16.1 LSTK Contractor shall provide the Fire Detection and Alarm System which shall be an independent system comprising of individual break glass type manual call points, automatic sensors e.g. smoke and heat detectors, main panel, repeater panel, hooter, battery, battery charger and any other hardware.

16.2 The system shall be designed to provide audio-visual indication at the main panel to be located in Control Room and repeater panels shall be provided in fire station.

16.3 The manual call points shall be provided at strategic locations with access along all exit routes and roads.

16.4 Electrical sirens shall be provided to cover entire Steam Generation Plant. Hooters and exit lights shall be provided at required locations in the buildings.

16.5 Panel design and component selection shall be done for future extension upto 10% of specified zones or one zone, whichever is maximum in each panel. The design of common facility and hardware shall be provided for required future extension of zones.

16.6 The fire detection system shall be interfaced with fire suppression system.

16.7 Supply, installation, testing and commissioning of above mentioned components/equipment for plant area, substation & control room shall be by the Contractor along with necessary supply and laying of required signals cables.

16.8 The required nos. of MCPs and detectors in substation & control room shall be calculated as per IS norms and contractor shall get approval from client during detailed engineering stage.

16.9 Separate Centralised Fire Alarm & Detection System of entire fertiliser complex shall be provided by EDS LSTK Contractor. Fire Alarm & Detection System of Steam Generation Plant shall be hooked-up with the Centralized Fire Alarm System and shall be in LSTK
Contractor’s scope. All interfacing equipment as well as cabling required for hook-up shall be in LSTK Contractor’s scope.

16.10 All cables (including communication cables) shall be armoured type only.

16.11 For all other specifications refer PC150-TS-0826.

**17.0 COAL HANDLING AND ASH DISPOSAL HANDLING SYSTEM**

17.1 The Electrical system shall be suitable for the full capacity of coal conveying and ash disposal system.

17.2 Suitable switchgears, motors, cabling etc, for these systems shall be as described in the Electrical design philosophy under these headings.

17.3 Conveyor Control Panel (PLC based).

The conveyor control panel (CCP) is required to perform the various control operation to obtain the material flow in the desired patterns. Vendor to develop control schematic diagram, trip/interlock logics and furnish the same for the safe & proper operation of all conveyor motors.

The important parameters and data of CCP to be communicated to main control room DCS with suitable communication protocol.

**Emergency Safety Devices**

17.3.1 Following emergency safety device shall be provided at the provided at the specified intervals to trip the conveyor under abnormal operating conditions:-

   i. Pull cord switch
   ii. Belt sway switch
   iii. Zero speed switch
   iv. Emergency stop push button
   v. Gravity take up switch
   vi. Chute choking device
   vii. Bunker level indicating device

In addition status of all safety switches on CCP also to be also provided.

17.3.2 Pull Cord Switch

   a) The pull card switch shall be installed only on the normal walk way side of each conveyor at an interval of 30 meters with a minimum of one for each conveyor for tripping the conveyor under emergency.

   b) The switch shall be heavy duty type pedestal mounted, enclosed in a dust proof cast aluminium IP-65 enclosure/stainless steel IP-65 enclosure with removable cover, complete with rope clamping arrangement and a set of normally open/normally close contacts rated or open on the operation of deriving shaft through the lever which shall be actuated by pulling the flexible steel wire rope of about 5 mm dia.

   c) The operating position of the switch shall have latches for safety purpose and resetting of the latch shall only possible by local manual operation. The lever shall operate on either side of its normal vertical axis.

   d) The switch shall be provided with sturdy terminal spring to take the tension of 100 meters long steel wire rope. An arrangement for the adjusting the angle of lever on the shaft shall be provided. The switch shall be complete with a set of normally open/normally close contacts rated for 10 Amps, 240V A.C for alarm and trip. 1 no. of earthing terminal, compression type brass nickel coated cable glands, terminal blocks and cable lugs etc. for termination of 3X2.5 sq.mm PVC insulated armoured and PVC
sheathed copper conductor cable. The complete details, of limit switch and assembly sketches shall be furnished.

17.3.3 Belt Sway Switch

17.3.3.1 The belt sway switches shall be provided along with timer (range 2 min. to 15 min.) to stop the conveyor in case of excessive sway in the belt on either side. These shall be mounted on the both side of the conveyor at an interval of 50 meters or minimum one pair for shorter length of conveyor. The switch shall be heavy duty type, enclosed in dust and weather proof cast aluminium IP-65 enclosure/stainless steel IP-65 enclosure.

17.3.3.2 The switch shall comprise of horizontally mounted spring return type vertical lever which shall be suitable for operation on its neutral vertical axis, a roller fitted on the lever which is suitable to rotate around its vertical axis. The resetting of the switch shall be possible by local manual operation. The switch shall be complete with a set of normally open/normally close contacts rated for 10 Amps, 240V A.C for alarm and trip. 1 no. earthing terminal, compression type cable glands suitable for 3x2.5 sq. mm (Cu) control cable, cable lugs, terminal block etc. The complete details of switch and assembly sketch shall be furnished.

17.3.4 Zero Speed Switch

a) The zero speed switch with timer of suitable range shall be required to provide adequate protection to conveyor against the following:-
   - Excessive belt slip and belt under speed.
   - Belt breakage or snapping

b) The switches shall be provided one per conveyor. The switches shall be heavy duty type enclosed in dust and weather proof cast aluminium IP-65 / stainless steel IP65 enclosure. The switch shall be turn on mounted type having centrifugal switch chamber on one side and extended rotating spindle with pulley at other end.

c) The pulley mounted on the spindle shall be so designed that it shall be able to rotate with the friction against the belt surface with as minimum slip as possible. The arrangement shall be provided to adjust the belt speed within the desired limits. This shall be mounted on the tail end side of the conveyor.

d) The switch shall be complete with a set of normally open/normally close contacts rated for 10 Amps, 240V AC, and 1 no. earthing terminal, cable glands, suitable for 3X2.5 sq.mm copper conductor control cable, cable lugs, terminal block etc. The complete details of the switch and assembly sketches shall be furnished.

17.3.5 Emergency Stop Push Button

a) The stop push button shall be provided in staggered manner at an interval of 20 meters with a minimum of one on each side of conveyor for tripping the conveyor under emergency.

b) The push button shall be heavy duty type enclosed in dust and whether proof cast aluminium enclosure / SS enclosure and shall be suitable for wall/structure mounting.

c) The push button shall be red colored, un-shrouded type having a set of normally open/normally closed contact rated for 10 Amps, 240V AC and shall have padlocking facility. The push button shall be complete with 1 no. earthing terminal cable glands suitable for 3X2.5 sq.mm copper conductor control cable, cable lugs and terminal block etc.

17.3.6 Steel Wire Rope & ‘U’ Clamps

a) Galvanized steel wire rope shall be 6/19 construction, ordinary right hand lay, 5 mm dia. conforming to IS-3459 and provided with PVC sleeve of suitable thickness.

b) The steel wire shall be provided all along with conveyor with one end tied to ‘U’ clamp and other end to lever of pull cord switch Steel ‘U’ clamp fabricated out of 50X7 flats, complete with all nuts & bolts for fixing 5 mm dia. galvanized steel wire rope. The ‘U’
clamp shall be duly painted to withstand the corrosive chemical atmosphere prevailing inside the conveyor gantries due to coal/urea dust.

17.3.7 KLAXON

a) Electric Klaxon, heavy duty type, enclosed in a dust and weather proof cast aluminium epoxy painted enclosure, suitable for still air range of 250 meters and rated for half hour at 240V single phase 50Hz AC supply.

b) The Klaxon shall be provided all along with conveyor at an interval of 100 meters apart with a minimum of 1 per conveyor and 1 per transfer tower and at any convenient location to sound the alarm before the start up of plant.

17.3.8 Other Electrical Items

All other electrical items shall be suitable for the duty involved and service Conditions.

18.0 Electric Heat Tracing System

18.1 Electrical trace heating of pipelines, instruments and equipment for process temperature maintenance shall be considered if required from process point of view.

18.2 Electrical trace heating system shall be designed according to IEC 60079-30 and shall be based on the use of self-regulating cables, suitable for installation in accordance to hazardous area classification.

18.3 Mineral insulated cables shall be used only where process temperature maintenance high values would not allow the use of self-regulating cables.

18.4 All self-limiting parallel resistance type heater cables shall be covered with a metal braid and a polymer over jacket for mechanical protection and corrosion resistance.

18.5 Cable sheaths, conductor and termination materials, and cable support clamps shall withstand the maximum operating temperature, temperature cycling and thermal expansion of the piping or equipment to which is applied.

18.6 The design of the heating system shall be such that the heater element temperature does not exceed the temperature classification of the hazardous area.

18.7 Heat tracing system shall be fed through a separate control station approachable to operator and suitable ammeter shall be provided to ascertain that heat tracing cables are working.

18.8 System shall be designed for tripping in case of leakage to earth or pipe for human safety.

19.0 MOUNTING STRUCTURES

Switch sockets, cable trays, DBs etc shall be mounted / supported on suitable structure fabricated out of standard sections of mild steel, i.e. channels, angels, flats etc conforming to IS: 2066.

20.0 SPARES

20.1 Commissioning Spares

LSTK Contractor shall recommend list of commissioning spares for all the equipments, as required. The commissioning spares shall form an integral part of the scope of supply. LSTK Contractor shall be responsible for the quantification of the commissioning spares for the smooth start up of the plant/package system. Item wise list of commissioning spares with recommended quantity shall be furnished for information. The same shall be Part of LSTK Price.

20.2 Mandatory/Insurance spares

Contractor shall supply Mandatory / Insurance spares for all equipments as per Section 10.0: Spare Parts of this bid package. The same shall be Part of LSTK Price.

20.3 2 Years Bidder’s Recommended Operational Spares (Other than Spares for 2 Years Operation & Maintenance)
Bidder shall recommend 2 years Operational Spares for all the equipment (item-wise) with recommended quantity and unit price. The item-wise price shall be with validity of 2 Years. The same shall not be part of LSTK price.

20.4 All spare parts shall be identical to the parts used in the equipments.

20.5 Any other spare parts or special tools not specified, but required, shall also be quoted along with the offer.

21.0 VENDORS’ SERVICES

21.1 The LSTK Contractor shall consider the services of major equipment suppliers during installation, testing and commissioning in their scope as required.

21.2 The services of engineers of following equipments’ (OEM) manufacturers are envisaged and required during installation, Testing and commissioning. LSTK contractor shall arrange for the same without any additional cost implication:

- AC UPS
- DC Panels
- Variable Speed Drives / Soft Starter
- Numerical relay
- MOV
- DG sets
- Power Transformer
- HV & LV Switchboard
- Cathodic Protection System
- Public Address System
- Fire Detection & Alarm System
- Lift

21.3 Site Testing, parameterization and commissioning of the Numerical relays shall be done by OEM expert only.

22.0 TESTING & INSPECTION

22.1 Testing of all electrical equipments shall be done in accordance with relevant IEC/BIS codes in presence of owner’s representative at manufacturer’s works before despatch / at site before installation. All such tests shall be arranged by the contractor and testing charges, if any, shall be borne by the contractor.

22.2 The LSTK Contractor shall submit the certificates of type tests performed on identical equipment as evidence of the compliance of the equipment with the type tests.

22.3 The LSTK Contractor shall submit the certificates of routine and acceptance tests conducted on the purchased equipments.

22.4 All the routine/acceptance tests shall be performed at the manufacturer’s works in the presence of owner’s representative.

22.5 Stage Inspection of Electrical Equipment shall be considered. The owner or their representative shall be allowed to visit the manufacturing works for stage inspection during manufacturing stage.

22.6 The equipment shall be dispatched from works only after receipt of Owner written approval of the test reports.

22.7 The LSTK Contractor shall intimate the owner 4 weeks in advance of the tests and submit the detailed schedule of tests.

22.8 In addition, the equipment shall be inspected at site for final acceptance.

22.9 Certified reports of all the tests carried out at the works shall be furnished in six (6) copies for approval of the Owner.
22.10 Electrical installation work shall be subjected to inspection by owner / his authorized representative, statutory bodies like Electrical Inspector, Factory Inspector and where applicable by equipment supplier’s engineer. The contractor shall carry out without extra cost to owner rectifications / modifications desired by the above authorities to make the installation conforming to I.E. Rules etc.

22.11 The owner may reject any portion of the work considered defective or of poor workmanship and the contractor shall make good these defects without extra cost to owner.

23.0 DOCUMENTATION

23.1 The LSTK Contractor shall submit the documents for electrical equipments (MS-word, MS-excel and AutoCAD) as per the drawing and documentation schedule as given in this bid package.

23.2 Sizing of Electrical system and Equipments shall be submitted during detailed engineering stage.

23.3 A dedicated PC with licensed copy of documentation software shall be included in the scope of LSTK Contractor for documentation of Electrical Engineering.

23.4 The software shall be used for preparing and updating the various documents such as general arrangement drawings, cable schedules, single line diagrams, control system drawings and equipment specifications etc.

23.5 The documentation software shall be same which is used by the LSTK Contractor for electrical documentation.

23.6 The details of the documentation software shall be furnished in the technical offer.

23.7 LSTK Contractor shall ensure that following shall be mentioned in each sheet of drawings/documents in the order mentioned below:

(a) Logo and Name of the client
(b) Logo and Name of the consultant
(c) Logo and Name of the contractor (LSTK Contractor)
(d) Logo and Name of the Manufacturer on the drawings prepared by manufacturer, if applicable
(e) Name of the Project for which drawings are applicable
(f) Title of the drawing (Title shall indicate the details shown in the drawing)
(g) Drawing/ document number with sheet number and number of total sheets in the drawing (Drawings having different title shall be assigned different drawing number)
(h) All sheets of each drawing shall bear same title, same document number and same revision number

23.8 At the time of handing over of the installation, LSTK Contractor shall supply as built drawings taking into consideration the actual execution carried out at site.

23.9 Erection, testing/ checking (inclusive of calibration check) prior to energisation/ after energisation and commissioning Manuals shall be in bound book format and shall give step by step procedure for:

(a) Storage, Handling and Erection
(b) Checking/ testing after erection and before energisation.
(c) Pre-commissioning tests/ checks and cold trials
(d) Commissioning
(e) Drawings relevant for erection, operation, maintenance and repair of the equipment.
(f) List of instruments/ testing kits/ sets, measuring instruments etc. required for testing/ checking with specification, ratings, ranges etc.

23.10 Operation & Maintenance Manuals for each of the equipment/ system being shall be in bound book format and shall be supplied alongwith dispatch of equipment and inclusive of following:

(a) Log sheets indicating daily/ hourly recordings of parameters to be noted down by customer's operating personnel.
(b) Procedure for shut down and energisation.
(c) Preventive maintenance schedule.
(d) Safety procedures for safe operation of equipment and complete system.
(e) Specification of equipment installed. Manufacturer’s catalogues operation and maintenance manuals for all types of relays/components used.
(f) Test procedures for site tests/ checks.
(g) Spares list for each equipment/ system for 2 years operation and maintenance.
(h) Relevant calculations and protection relay setting table for the equipment/ system being supplied by him
(i) Instructions for Diagnostic trouble shooting / fault location charts
(j) Tests for checking of proper functioning/ Operation.
(k) Storage and re-conservation Manual
(l) Safety Manual
(m) Drawings relevant for operation, maintenance and repair of the equipment
(n) Instructions for Maintenance and Repair
(o) List of spare parts with ordering specifications and manufacturer's catalogues.
(p) List of consumables with specifications, brand names and annual consumption figures.
(q) Manufacturer’s catalogues with ordering specification for all items
(r) List of special tools and tackles
(s) QAP, Internal Test Certificates and Inspection Certificates
(t) Procedure for ordering spares.
(u) All as built drawings.

23.11 Drawings/ documents to be submitted with inspection call of equipment:

(a) Type test certificate for identical equipment
(b) Sub-supplier’s/ vendor’s catalogue/technical literature
(c) Test reports for internal inspection
(d) Test certificates of components
(e) Technical specification & data sheets of equipment
(f) All drawings as applicable of category ‘Approved’, ‘Approved with comments’ and drawings ‘For information/ Reference’ including comments thereon

23.12 The details of equipment layout and cable routing will be designed by the LSTK Contractor during detail engineering stage and these shall be subject to approval by Owner/Consultant. Changes as required to achieve a neat layout with adequate working space all around, for
better aesthetics as well as to meet statutory regulation and codes shall be done without any
time and cost implication.

24.0  **TOOLS & TACKLES**

The LSTK Contractor shall supply at least one set of all special tools for each substation
required for maintenance of the equipment supplied by them and price shall be included in
the offer. List of tools & tackles with quantities shall be mentioned in the offer.

25.0  **REVIEW OF DRAWINGS & DOCUMENTS BY OWNER/ CONSULTANT**

25.1 The successful Bidder (herein after referred as contractor), shall submit within one month of
placement of LOI; list of drawings/ documents/ Manuals that would be submitted by them. The
list shall mention Serial Number, Title of the drawing/ document/ manual, Category (For
Approval, For review, For Reference, etc) and tentative date of submission. The list shall be
prepared taking in to account into consideration stipulations in respect of submission of
drawings/ documents and scheduled date for completion.

25.2 Template for name plate of drawings, documents and drawing/ document numbering system
shall also be submitted by contractor and approval obtained.

25.3 The LSTK Contractor shall ensure that all sheets of the drawings/ documents and top sheet
of manual prepared by manufacturer/ vendor/ supplier & submitted by him or by his
consortium member or by manufacturer or his consultant, are checked by him/ leader of
consortium and vetted by LSTK Contractor / Leader of consortium before submission with
stamp ensuring correctness, completeness, suitability of document for subject work and
compliance with stipulations of order

25.4 The responsibility for delay in approval/ review of drawings/ documents due to

a. Submission of incomplete drawings/ documents not meeting the requirement of
project/ stipulations of order

b. Non-compliance of comments made earlier

c. Drawings are not submitted in requisite copies;

and consequent delay in project shall be that of contractor.

25.5 The contractor shall ensure that in case any model number is mentioned in the drawing,
detailed technical catalogue, literature, explanatory notes to describe the model and its
technical details in full are also submitted along with the drawing. Such drawings/ documents
should be assigned Drawing/ Document Number, Number of sheets in the drawing, Rev
number etc (Unique Identification). Reference of such drawing/ document number should be
mentioned in the drawing.

25.6 The drawings/ documents shall be prepared in such sizes that those can be read easily.
Size of font in print submitted shall not less than size10 Arial or equivalent.

25.7 The drawings/ documents shall be submitted in sizes in which those are prepared.
Photocopies in reduced sizes shall not be accepted.

25.8 The contractor shall leave space on each sheet for stamping the drawing by Owner/
consultant to avoid stamping on contents of drawing making them unreadable. Submission
of drawings in A4 size shall be avoided.

25.9 All sheets of a drawing shall be assigned same title and drawing number. Drawings having
different title shall be assigned different drawing numbers.

25.10 GA drawings, schematic diagrams, single line diagrams, bill of material, data sheets,
characteristics curves, cable schedules and cable termination diagrams shall be assigned
separate drawing numbers.

25.11 Revision shall be clearly marked on all subsequent issue of drawings and documents.
25.12 Inability to incorporate some of the comments shall be clearly stated by contractor with reasons and without delay. However, to accept or reject the non-compliance based on the reasons indicated by contractor shall be discretion of Owner/their consultant.

25.13 In case alterations are considered necessary by the contractor in the drawings already approved, such drawings shall be resubmitted for approval again stating the considerations necessitating changes/alterations. In case, alterations/changes proposed by contractor are approved by the consultant/Owner; all other drawings and data affected by such alterations/changes shall be duly revised and re-submitted for the approval as stated above.

25.14 Contractor shall depute their concerned engineers (with the engineers of suppliers, if required) shall visit consultant after submissions of drawings for discussion, modification of drawings and approval so that project is not delayed for want of approval of drawings.

25.15 It will be the responsibility of contractor to submit the drawings and obtain approval to meet the project schedule. Delay in approval of drawings due to following shall be the responsibility of contractor:
   a. non-submission of drawings/documents well before those are actually required and/or
   b. delay in incorporation of comments and/or
   c. non-incorporation of comments by contractor and/or
   d. submission of drawings without checking and ensuring requirement stipulated in contract/order

25.16 Contractor shall note that any approval and/or clearance accorded by Owner or consultant for manufacture and/or to proceed further given during discussions or recorded in the minutes of the meetings shall be valid only after the drawings showing relevant details are submitted by contractor and clearance/approval is accorded by Owner/Consultant by stamping and signing on the relevant drawings.

25.17 Approval of drawings by Owner/his consultant shall not relieve the contractor of his contractual obligations and responsibility for engineering, design, workmanship, materials and performance of the equipment.

25.18 Contractor shall furnish, if requested, additional drawings, calculations, information to the Owner/Consultant to enable him to examine/study the drawings submitted.

25.19 Contractor shall note that work shall be carried out exactly as indicated in the approved drawings and no alterations shall be made without the written approval of the Owner/Consultant.

26.0 TRAINING

26.1 Training shall be imparted to owner's personnel at manufacturer’s works as under:
   a) AC UPS: Two engineers for one week.
   b) Variable Speed Drive / Soft Starter (if required): Four persons for one week.
   c) DC System: Two engineers for one week.
   d) Numerical relay: Two engineers for one week

27.0 VENDOR LIST

27.1 Make of all electrical equipment shall be as per Section 15.0: Vendor List attached with this bid package.

27.2 Any other vendor shall be subject to Owner/Consultant’s approval.

27.3 Bidder shall indicate the make of all the equipments in their offer.
27.4 Any other item for which vendors are not mentioned in NIT, LSTK Contractor shall furnish list of proven suppliers with PTR subject to Owner’s/ Consultant’s approval during detailed engineering. Document(PTR) shall be in English language only.

28.0 INSTALLATION, TESTING AND COMMISSIONING

28.1 The LSTK Contractor shall undertake installation of all electrical equipment in accordance with latest code of practices, in conformity with recommendation of the respective equipment manufacturers, drawings approved by the owner or owner's representative, direction of engineer-in-charge, statutory regulations and to the entire satisfaction of the owner.

28.2 The LSTK Contractor shall arrange all the necessary erection tools and tackles, testing and measuring instruments and shall supply the required erection materials including structural steel.

28.3 LSTK Contractor shall furnish field inspection and test data sheets for all equipments for owner's approval.

28.4 The LSTK Contractor shall obtain the necessary certificate of compliance/completion certificate with test results from statutory authorities as required. All necessary drawings and test certificates as required by them shall be furnished by the vendor.

28.5 The erection work shall be supervised by competent supervisors holding relevant supervisory license from the Government.

28.6 Installation of Equipment

a. The equipment shall be installed in switchgear rooms, MCC rooms, control rooms and at shop floors.

b. The scope of work of LSTK Contractor under installation shall be inclusive of but not limited to the following:

c. Physical inspection and handling
d. Assembly and interconnection of shipping sections, if any, as per manufacturer's instructions. Supply of materials, fabrication and installation of supporting frames/ brackets for proper support of equipment/ panels/ devices/ cable trays etc..

e. Installation on foundation/ supports/ brackets.

f. Alignment, leveling and clamping/ welding/ fixing/ grouting with supports/ foundation bolts as required.

g. Mounting loose supplies and connection of wiring.

h. Conducting pre-energisation tests/ checks to ensure that installation is carried out as per manufacturer’s instructions/ direction of supervising engineer and is healthy/ fit for energisation.

28.7 Cable Installation

28.7.1 General

(a) All Cables to be laid in overhead cable tray only. Cable Tray for HV, LV and Control cable should be separate. Underground cable to be avoided, Cables to be laid on racks in underground concrete cable trenches inside the plant only where overhead structure is not possible. Cables may be laid in ground (slit with HDPE conduit) where number of cables to be laid are less and do not justify use of concrete cable trenches.

(b) All the cable tray structures shall be painted with two coats of primer and two coats of final paint after necessary surface preparation.
(c) Cable OD 40 MM and above shall be clamped individually.

(d) Cables shall be clamped only after the cables are neatly arranged, dressed tailored and kept in position. Support of cables on edges of cable trays/ structural steelwork shall be avoided.

(e) Power cables shall be laid in one layer only. Control and other cables may, however, be laid in two layers. More than two layers shall not be permitted.

(f) All the cable tray network shall be earthed by a continuous earth strip.

28.7.2 Cable laying in Trench/ on Racks/ Trays/ Cleated on Wall/ Structure. For proper support, access and neatness of appearance of installation; cables shall be laid on racks or cable trays or cleated on wall and/or structure taking following into consideration:

(a) Cable racks/ trays shall be 250 mm apart.

(b) Ladder type GI cable trays shall be used for laying power cables.

(c) Perforated type GI cable trays shall be used for laying control, signal, and communication etc. cables.

(d) Cable racks around cooling tower areas shall be of heavy duty FRP (fire retardant and UV stabilized) material.

(e) Coaxial cables for data transfer from/to microprocessor based equipments shall be laid in HDPE conduits with pull boxes fixed to cable supporting racks.

(f) Top tray shall be used/ left vacant for communication, signaling and fire alarm cables.

(g) Cables shall be laid in separate trays according to voltage and noise classification. Fire proof partition shall be provided between HV and LV cables.

(h) Power, control and lighting cables shall be laid in separate cable trays.

(i) Large size cables shall be clamped individually. Small size cables may be bunched together provided that in any bunch all cables have sheath of same material.

(j) Cables in trays shall be clamped at not more than every 1500 mm for horizontal run and 800 mm for vertical run and near bends.

(k) Cable racks/ trays shall be planned in such a way so that at least 20 % or one rack/tray (whichever is more) can be added in future and at least 20 % free space shall be left in each cable tray for cable laying in future.

(l) Support to cable trays shall be provided at intervals as required for proper support but at interval not more than 1000 mm.

(m) Support to trays shall also be provided at each joint of tray irrespective of it's distance from adjacent support.

(n) GI trays shall be fixed using nuts and bolts as welding will not be permitted.

28.7.3 Cable laying in conduits

(a) Cables shall be laid in GI conduits while laying on or crossing floors/ wall/ railway lines/ roads.

(b) While laying on floor or wall or crossing roads conduits shall be embedded in concrete/wall.

(c) When laid on floor the top cover shall be minimum 10 mm.

(d) At rail/ road crossings, the conduits shall be laid not less than 1 meter below top surface of the road.

(e) Mechanical protection by G.I. Pipe shall be provided to all cables up to 1200 mm from ground/ floor level.
(f) Minimum diameter of G.I. pipes used for laying/ protection of cables shall be 1.6 times the cable diameter.

(g) Only one cable shall be laid in one conduit.

(h) Conduit shall be sealed after cable laying.

(i) Standard bends or fabricated bends shall not be used. Wherever required, conduits shall be bent using bending machine. Bending radius shall not be less than 10 times the diameter of conduit.

(j) Jointing of the conduits shall be done using sockets which may be welded from top to avoid ingress of water.

(k) Ends of conduits shall be made smooth to avoid damage to cables.

28.7.4 Cable Jointing

(a) Joints in cable length less than standard drum length shall not be allowed.

(b) Joints, if unavoidable, shall be made at most suitable places.

(c) Joints shall not be made at passageways or under rail/ road crossings and in hazardous area.

(d) Joints shall be segregated by not less than 2 meters so as to reduce the possibility of one joint failure affecting the other.

(e) Individual cores in cables shall always be joined number to number or colour to colour of the insulation over the conductors.

(f) Continuity and current carrying capacity for earth conductor and/or armour shall be provided.

(g) Cable jointing shall be done by joiners who possess certificate of competency for carrying out particular joint.

(h) Minimum 2 meters cable loops shall be kept near each joint.

28.7.5 Cable Termination

(a) Double compression heavy type glands/ heat shrinkable termination kits and bi-metallic/ copper lugs shall be used for termination of cables.

(b) Paint of the gland plate at the contact point of gland shall be removed for proper contact.

(c) Cable glands/ termination kits shall be earthed.

(d) Cables to individual cubicles shall be neatly laid out and supported.

(e) Cables shall be clamped at a distance of 400 mm from gland/ termination.

(f) Conductors of control cables shall be neatly arranged in compact group. The entire group shall be placed and tied with nylon straps.

(g) Spare cores shall be terminated with sufficient length to permit future connection to the terminal block associated with control cables.

28.7.6 Identification

(a) Cable tags shall be made of non-corrodible material, preferably SS.

(b) Voltage, cable number etc shall be engraved on each tag.

(c) Cable tags shall be tied to each cable at

(i) All termination (outside as well inside panel/ box.)

(ii) All bends.
(iii) All points before and after which their route cannot be easily identified.
(iv) Entry and exit from conduits.
(v) All joints.
(vi) Every 15 meter for straight run.

29.0 TESTING OF INSTALLATION AFTER ERECTION

29.1 The LSTK Contractor shall carry out tests/ checks after erection of equipment/ cables to check, ensure and demonstrate the conformity of equipment supplied and installation done with the specification and statutory requirement.

29.2 Prior to starting the test, the LSTK Contractor shall satisfy himself and ensure that

   a. The installation is strictly in accordance with the specification, drawings and statutory requirement.
   b. Any automatic controls that might vitiate the tests have been relaxed.
   c. All instruments to be used for testing are suitable for the purpose and have been calibrated by a recognised laboratory within the last 12 months and copy of the calibration certificates have been submitted to the Owner/ Consultant.
   d. The testing, commissioning, operation and maintenance manuals are available to the testing engineer and Owner/ Consultant.
   e. Formats for recording test results have been finalised with the Owner/ Consultant and copies have been distributed to all concerned.

29.3 The skilled manpower to test all the equipment, cables, earthing etc deputed by LSTK Contractor is well aware of and prepared to perform checks/ tests.

29.4 The tests shall be witnessed by the representatives of Owner/ Consultant.

29.5 The LSTK Contractor shall compile and tabulate all the test results in agreed formats and submit to Owner/ Consultant for approval prior to acceptance of installation.

29.6 Testing and checking shall be carried out to demonstrate and record prior to completion, that supply and installation meets the requirement/ performances specified. The installation shall be tested in presence of Owner/ Consultant.

29.7 The LSTK Contractor shall give at least 24 hours notice to Owner/ Consultant to enable them to witness the test.

29.8 The LSTK Contractor shall submit to Owner/ Consultant test record sheets on daily basis.

29.9 Equipment or any part of the installation shall be energised only after all pre-energisation tests are completed and test results are approved by Owner/ Consultant.

29.10 Failure to submit test results as tests are completed may render the LSTK Contractor for carrying repeat tests.

29.11 The LSTK Contractor shall supply six (6) bound and indexed copies of all tests in agreed formats prior to preliminary acceptance and handing over of the equipment/ installation, duly signed by representatives of the Owner/ Consultant who have witnessed the tests.

29.12 It will be the responsibility of the LSTK Contractor to supply/ arrange at his own cost all necessary testing equipment and measuring equipment required for conducting the tests as per applicable standards.

29.13 Should any of the tests reveal any discrepancy or non-conformity, the same shall be attended to and retested before proceeding with any other tests.

29.14 All tests shall be conducted in accordance with this specification, standard specifications of Bureau of Indian Standards, recommendations of IEC and IE Rules.

29.15 Tests checks to done at site shall be inclusive of but not limited to the following:
a. Physical Check & Verification : All Equipment/Cables etc
b. Tightness of connections : All Equipment/Cables etc
c. Checking for cleanliness : All Equipment/Cables etc
d. Size & No. of Earth connection : All Equipment/Cables etc
e. Erection, alignment, mounting height and clearances : All Equipment/Cables etc

f. Insulation Resistance test : All Equipment/Cables etc
g. Earth continuity test : All Equipment/Cables etc
h. Earth Resistance test : All Equipment/Cables etc
i. Earth loop impedance test : All Equipment/Cables etc
j. No load & rated load current : All Motors/Loads
k. No load & rated load P.F. : All Motors/Loads
l. No load & rated load Power : All Motors/Loads
m. Functional checks : All Equipment & Controls
n. Primary injection test : All switchgear
o. Secondary injection test : All protective relays/devices
p. Ratio and polarity test : CTs
q. Power frequency HV test : Power & Control circuit
r. Phase sequence checks : /C & bus couplers
s. Winding resistance test : Motors & Transformers
t. Direction of rotation : All motors
u. Free running for 2 Hrs : All motors
v. Under voltage tests : All U/V Devices
w. Calibration Checks : All instruments
x. Load and Performance tests : UPS, PLC, & Variable Frequency equipment, Battery Bank
y. Checking of Voltage, current : UPS, PLC, & Variable Frequency equipment
z. Checking of specific gravity and acid level : Battery
aa. Illumination levels : All areas

29.16 It is anticipated that following equipment will be necessary to perform testing of the installation. The LSTK Contractor shall, therefore, arrange these as well as any other equipment for testing of the installation.

a. HV Testing Set
b. Primary Injection Set
c. Secondary Injection Set
d. IR Testers
e. Earth Continuity testers  
    f. Soil resistivity Testers  
    g. Earth resistance Testers  
    h. Phase to earth loop impedance testers  
    i. Mili volt drop testers  
    j. Micro-ohm meter  
    k. Phase sequence testers  
    l. Clip-on ammeters  
    m. Voltmeters  
    n. Power factor meter  
    o. Frequency meter  
    p. 3 Ph 4 wire unbalance load kWh meter  
    q. Cable fault location equipment  
    r. Digital multi-meter suitable for testing IC voltage and current levels  
    s. Analogue Multi-meters  
    t. Portable multi-range precision ammeters, voltmeters complete with CTs, PTs for AC/DC circuits.  
    u. Protection relay test plugs  
    v. Portable earthing equipment  
    w. Dual beam oscilloscope with storage facility.  
    x. UV recorder  
    y. Illumination level meter  
    z. Thermometers  
    aa. Power Analyser / Portable Power Meter  
    bb. Rpm meter  
    cc. Noise meter  

29.17 At least following tests shall be specifically conducted before commissioning in presence of owner’s representative. All the test results shall be recorded and submitted to the owner.  

a) Insulation Test  
   b) Continuity Test  
   c) High Voltage Test  
   d) Simulation Test  
   e) Earth Resistance Test  

29.18 The major testing equipment that are required to be provided by the contractor (permanent basis) are listed below :  

a) Power operated Megger-1 KV and 5 KV Grade (Make – Fluke)  
   b) Earth Resistance Megger, range 0-1/3/30 Ohms (Make – Fluke).  
   c) Tong testers of suitable ranges (Make – Fluke).  
   d) Torque wrench of various sizes.
30.0 QUALITY ASSURANCE

30.1 All equipment, components, materials proposed to be supplied by LSTK Contractor shall be procured, manufactured, erected, commissioned and tested as per a comprehensive Quality Assurance Programme (QAP) to be approved by the Owner/ Consultant.

30.2 The Successful Bidder shall submit within 1 Month of from order; Quality Assurance Plan (QAP) for all the equipment/ panels/ cables/ motors/ devices etc. under their scope of supply.

30.3 All routine and acceptance tests shall be carried out as per relevant IS / IEC/ Other Standards during inspection at manufacturer’s works in presence of Owner or his representative.

30.4 The LSTK Contractor shall submit type test certificates for similar equipment supplied by him elsewhere. In case type test certificates (not more than 5 years old and conducted at duly accredited laboratory) for similar equipment is not available, the type test shall be conducted in presence of Owner or his representative without any financial implications to Owner.

30.5 The inspection procedure shall be finalized and approved by Owner and/ or their consultant/ authorized representative.

30.6 Inspection will be carried out as per drawings and quality assurance plan approved by the Owner/ Consultant. Inspection shall be carried out either at manufacturer’s shop/ works or any other place where facilities for conducting tests/ checks are available.

30.7 Owner reserves the right to witness any of the tests and verify the documents of the LSTK Contractor, his supplier/ vendor/ manufacturer.

30.8 Manufacture test certificate for bought out components shall be submitted during inspection.

30.9 No equipment or part items shall be dispatched without final acceptance certificate and dispatch instructions in writing issued by Owner and/or their authorized representatives.

30.10 The LSTK Contractor shall carry out an inspection and testing programme during manufacture in his works and/ or that of his vendor’s works to ensure accuracy/ correctness/ completeness of components, compliance with drawings, conformance to functional and / or performance requirements, identify and acceptability of all materials, parts and equipment. The LSTK Contractor shall also carry out all tests/ inspections required to establish that the items/ equipment conform to requirements of the specification and the relevant codes/ standards specified in the specification in addition to carrying out tests as per the approved Quality Plan.

30.11 Quality audit/ surveillance/ approval of the results of the tests and inspection, approval of drawings will not, however, prejudice the right of the Owner to reject the equipment at any subsequent stage if it does not comply with the specification or does not give complete satisfaction in service and shall in no way limit the liabilities and responsibilities of the LSTK Contractor of ensuring complete conformance of the materials/ equipment supplied to relevant specification, standard, data sheets, drawings etc.

30.12 The owner or their representative shall be allowed to visit the manufacturing works for stage inspection during manufacturing stage.

30.13 The LSTK Contractor shall intimate the owner 4 weeks in advance of the tests and submit the detailed schedule of tests.

30.14 LSTK Contractor shall supply reports of type tests, acceptance tests, all requisite factory tests and site tests in bound volumes.

30.15 All the equipment shall be tested at site to know their condition and to prove suitability for energisation and required performance.

31.0 COORDINATION WITH OTHER CONTRACTORS
31.1 LSTK Contractor shall coordinate with Owner’s other Contractors and shall freely exchange all technical information required for this purpose.

31.2 All civil works connected with electrical installation shall be under the LSTK Contractor’s scope.

32.0 DEVIATIONS

32.1 Deviations, if any from this standard (clause wise) shall be clearly indicated in the offer with reasons thereof. In the absence of any such deviation the compliance to the clauses shall be deemed automatically.

32.2 Successful Bidder shall also note that all those deviations mentioned in bid but not accepted by Owner/Consultant in writing shall be considered as withdrawn by bidder.

32.3 Any and all deviations mentioned anywhere else in the bid but not specifically and unambiguously mentioned under specific section ‘List of deviations’ shall not be considered.
## ANNEXURE-I
### ILLUMINATION LEVELS

Average illumination levels (Mean Lux) for various areas shall be as follows:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>AREA</th>
<th>LUX</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 ROADS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Plant roads</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>1.2 Security roads</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>2.0 YARD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Marshalling yard</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>2.2 Loading/unloading areas</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>2.3 Open areas</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>3.0 PLANT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 Operating platforms</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>3.2 Non-operating platform/ general process areas &amp; walk ways</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>3.3 Pipe rack</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>3.4 Compressor house</td>
<td></td>
<td>150</td>
</tr>
<tr>
<td>3.5 Turbine Hall</td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>3.6 Pump house/Pump bay</td>
<td></td>
<td>250</td>
</tr>
<tr>
<td>3.7 Top of cooling towers</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>3.8 Boiler gallery</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>3.9 Area near large rotating equipment/plant</td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>3.10 Air Conditioning Plant Room</td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>3.11 Elevator machine Room</td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>3.12 Power House Coal conveyor floor</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>3.13 Conveyors, junction/transfer towers</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>3.14 ESP hopper area, platforms and ESP top</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>4.0 SUB-STATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1 Switch room - Front of panel</td>
<td></td>
<td>250</td>
</tr>
<tr>
<td>- Back of panel</td>
<td></td>
<td>150</td>
</tr>
<tr>
<td>- Battery room</td>
<td></td>
<td>150</td>
</tr>
<tr>
<td>4.2 Transformer room, cable room.</td>
<td></td>
<td>70</td>
</tr>
<tr>
<td>4.3 Outdoor/transformer bay</td>
<td></td>
<td>70</td>
</tr>
<tr>
<td>5.0 CONTROL ROOMS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1 Front of panel</td>
<td></td>
<td>500</td>
</tr>
<tr>
<td>5.2 Back of panel</td>
<td></td>
<td>200</td>
</tr>
<tr>
<td>6.0 OFFICES</td>
<td></td>
<td>300</td>
</tr>
<tr>
<td>7.0 STORES, BATH ROOM</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>8.0 STAIR CASES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.1 Safe areas</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>8.2 Hazardous areas</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>9.0 PANIC LIGHTING</td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

Lux level for A.C. Emergency lighting in Control Room shall be 250 lux.
TECHNICAL SPECIFICATION

PUBLIC ADDRESS SYSTEM
<table>
<thead>
<tr>
<th>SECTION NUMBER</th>
<th>DESCRIPTION</th>
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<td>3.0</td>
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<td>OPERATIONAL REQUIREMENTS</td>
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<td>5.0</td>
<td>TECHNICAL REQUIREMENTS</td>
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<td>6.0</td>
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<td>7.0</td>
<td>CABLES</td>
</tr>
<tr>
<td>8.0</td>
<td>CABLING</td>
</tr>
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<td>9.0</td>
<td>JUNCTION BOXES</td>
</tr>
<tr>
<td>10.0</td>
<td>EARTHING</td>
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<tr>
<td>11.0</td>
<td>ERECTION AND COMMISSIONING</td>
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<td>DRAWINGS AND DOCUMENTS</td>
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<td>13.0</td>
<td>SPARES</td>
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<td>14.0</td>
<td>PACKING</td>
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<td>15.0</td>
<td>DEVIATIONS</td>
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<td>ANNEXURE - I</td>
<td>DOCUMENTATION FOR PUBLIC ADDRESSS SYSTEM</td>
</tr>
</tbody>
</table>
1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing, delivery installation at site and commissioning of Public Address System along with all accessories.

1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of public address system and their accessories covered by this standard shall comply with the latest issue of the following and other relevant Indian Standards Equipment complying with equivalent IEC standards shall also be acceptable.

IS: 1881 - Code of practice for installation of indoor amplifying and sound distribution systems.
IS: 1882 - Outdoor installation of public address system-code of practice.
IS: 1301 - Code of safety requirements for electric mains-operated audio amplifiers.
IS: 8061 - Code of practice for design, installation and maintenance of service lines up to and including 650 V.
IS: 1490 - Recommendation for minimum performance requirements of mains-operated public address amplifiers.
IS: 1819 - Recommendation for general requirements of public address amplifiers.
IS: 1031 - Methods of measurements of loudspeakers and loudspeaker systems.
IS:1554 (Part1) - PVC insulated (heavy duty) electric cables for working voltages up to and including 1100 V.
IS: 694 - PVC insulated cables for working voltage up to and including 1100 volts.
BS: 2004 - Electric cables for working voltage up to and including 1100 volts.

2.2 The design and operational features of all the equipments offered shall comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy - Electrical.
3.2 System Details

These shall be as indicated in Design Philosophy - Electrical.

4.0 OPERATIONAL REQUIREMENTS

The public address system and their associated accessories shall be suitable for operating continuously under the ambient conditions and with the voltage and frequency variation without exceeding temperature rise limits as per relevant standards and without detrimental effect on any part.

5.0 TECHNICAL REQUIREMENTS

5.1 The public address system shall be microprocessor based, non-EPABX distributed amplifier type. It should be designed for communication between various process units and office areas of an industrial plant and various control room(s).

5.1.1 The band width of the communication system shall not be less than 9 KHz for intelligible speech reproduction required for industrial environment.

5.1.2 The system shall comprise of:
   i) Microprocessor based central exchange
   ii) Master control station(s)
   iii) Field stations and junction boxes, if any
   iv) Power supply unit
   v) Cables
   vi) Loudspeaker

5.1.3 All other items not specifically mentioned, but required for the completeness of the system shall be supplied.

5.2 Microprocessor based central exchange

5.2.1 The exchange shall be rack mounted microprocessor controlled. It should be designed such that future extensions or modification can be easily carried out.

5.2.2 The actual control of communication shall be from the exchange. From the exchange, various system information and data shall be acquired, processed and communication links between stations shall be established as per user requirement through master control station.

5.2.3 The exchange shall be 100% redundant in hot standby mode. The exchange shall have facility for hooking up with the existing EPABX system. It shall have two independent lines of communication viz. page & party.

5.3 Master control stations (MCS)

5.3.1 The MCS shall be desk mounted type and shall comprise of a keyboard with LEDs, a built-in loudspeaker and a built-in dynamic noise cancelling goose neck microphone. It should have facility for duplex mode of communication.

5.3.2 The MCS shall have a key to initiate an EPABX call and should have facility to receive EPABX call.

5.3.3 The MCS shall have features to initiate the following type of call:
   i) All call
   ii) Alarm call
iii) Conferencing
iv) Inter MCS call
v) Call from MCS to field station & vice-versa
vi) Global call
vii) Call from field station of one MCS to field station another MCS

5.3.4 The MCS shall have drop out facility i.e. after connecting two field stations, the MCS, if required, may drop out of the ongoing conversation. Priorities shall be assigned to the various calls (Alarm & Global) shall have higher priority than other calls.

5.4 Field Station

5.4.1 It shall be of cast aluminium (LM-6) enclosure and shall consist of adequate capacity amplifiers for page channel, telephone type handset (but made of unbreakable material and of different size to make it pilfer proof), cradle switch and all other necessary control switches & push buttons required for satisfactory operation of the system.

5.4.2 Handsets shall be completely factory wired up to terminal blocks and shall be provided with cable termination accessories for connecting external cables.

5.4.3 The field stations shall be suitable for hazardous area classification defined as zone I/II, gas group IIA/IIB/IIC & temperature class T3. All master control station shall be suitable for outdoor installation with IP-65 protection.

5.5 Loudspeaker (LS)

5.5.1 Loudspeaker shall be highly efficient, high power driver unit designed for non-ringing to deliver clear reproduction. The driver unit shall be lockable type to avoid pilferage.

5.5.2 Loudspeaker shall be provided with impedance matching transformer. Transformer shall have the minimum “frequency characteristic” required for public address system.

5.5.3 Loudspeaker for indoor mounting shall be direct radiator, permanent magnet moving coil type rated for 15W. However, loudspeaker for outdoor mounting and in areas with high ambient noise level shall be pressure unit operated, projector or horn type, weatherproof, rugged die-cast aluminium construction rated for 15W.

6.0 POWER SUPPLY

6.1 Power supply single phase, 240 V, 50 Hz and further distribution shall be arranged by the vendor.

6.1.1 DC supply, if required, shall be arranged by the vendor from the dedicated power supply unit working on single phase 240 V, 50 Hz supply.

6.1.2 The system shall be provided with a transistorised type UPS of one hour back-up and the battery used shall be Nickel-Cadmium type.

7.0 CABLES

7.1 Signal and loudspeaker cables shall have annealed tinned copper, twin twisted & colour coded, PVC sheathed, GI round wire armoured and PVC overall sheathed. Loudspeaker cables shall be of 24 / 0.2 mm copper and signal cable shall be of 16 / 0.2 mm copper.

7.1.1 For power cables, 3 core 2.5 sq. mm annealed tinned copper, PVC insulated armoured cables are required.

7.1.2 The bidder shall indicate the details & quantity of cables required in tabular form.
8.0 CABELING

The contractor shall supply, lay & connect at both ends all the cables with accessories. The cables shall be accommodated in the existing overhead cable racks / structures as far as possible; where racks are not available, the cables shall be laid underground by using GI protection pipes.

9.0 JUNCTION BOXES

The junction boxes shall be of die cast aluminium powder coated. These shall be complete with inspection cover, conduit glands and terminal stripes. The cover shall be gasketted to make it dust & vermin proof and IP-55 protection. Holes for screwing the covers shall have stainless steel inserts.

10.0 EARTHING

All the equipment and their associated accessories of public address system shall be provided with earthing terminals and shall be connected to the ground mat by vendor as per relevant Indian Standard.

11.0 ERECTION & COMMISSIONING

The bidder shall include complete, testing & commissioning along with fittings & accessories in their scope. Good engineering practice in conformity with latest Indian Standard & code of practice shall be followed for erection & commissioning of all the accessories of public address system.

12.0 DRAWINGS AND DOCUMENTS

12.1 Drawings and documents as per Annexure-I shall be supplied unless otherwise specified.

12.2 All drawings and documents shall have the following description written boldly.
   i) Name of client
   ii) Name of consultant
   iii) Enquiry / order number with plant / project name
   iv) Equipment Code no. and Description

13.0 SPARES

13.1 Spares for operation and maintenance
   Item wise unit prices of spare parts with recommended quantity shall be quoted.

13.2 Commissioning Spares
   Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

13.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

13.4 All spare parts shall be identical to the parts used in the equipments.
14.0 PACKING

The public address system shall be properly packed to safeguard against weather conditions and handling. It shall be wrapped in polythene bag with an additional wrapping of bitumen paper to make it completely waterproof before the equipment is packed in wooden crates.

15.0 DEVIATIONS

15.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
ANNEXURE - I

DOCUMENTATION FOR PUBLIC ADDRESS SYSTEM

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Documentation</th>
<th>Documents Required (Y / N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>With Bid</td>
</tr>
<tr>
<td>1.</td>
<td>Guaranteed technical particulars</td>
<td>N</td>
</tr>
<tr>
<td>2.</td>
<td>Outline drawing showing dimensions and other details.</td>
<td>N</td>
</tr>
<tr>
<td>3.</td>
<td>Complete assembly drawings of equipments showing plan, elevation and cross section.</td>
<td>N</td>
</tr>
<tr>
<td>4.</td>
<td>Schematic of field stations of each type.</td>
<td>N</td>
</tr>
<tr>
<td>5.</td>
<td>Cable schedule with complete layout drawings</td>
<td>N</td>
</tr>
<tr>
<td>6.</td>
<td>Illustrative and descriptive catalogues</td>
<td>N</td>
</tr>
<tr>
<td>7.</td>
<td>Installation, operation &amp; maintenance manual</td>
<td>N</td>
</tr>
<tr>
<td>8.</td>
<td>Quality assurance program</td>
<td>N</td>
</tr>
<tr>
<td>9.</td>
<td>Type test certificate for</td>
<td>N</td>
</tr>
<tr>
<td>i)</td>
<td>Hose proof items</td>
<td>N</td>
</tr>
<tr>
<td>ii)</td>
<td>Flame proof items</td>
<td>N</td>
</tr>
<tr>
<td>10.</td>
<td>Test certificates</td>
<td>N</td>
</tr>
<tr>
<td>11.</td>
<td>Guarantee certificates</td>
<td>N</td>
</tr>
</tbody>
</table>

Note:
1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
TECHNICAL SPECIFICATION

UNINTERRUPTED POWER SUPPLY
## CONTENTS

<table>
<thead>
<tr>
<th>SECTION NUMBER</th>
<th>DESCRIPTION</th>
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<tr>
<td>2.0</td>
<td>STANDARDS TO BE FOLLOWED</td>
</tr>
<tr>
<td>3.0</td>
<td>AMBIENT CONDITIONS &amp; ELECTRICAL SYSTEM CHARACTERISTICS</td>
</tr>
<tr>
<td>4.0</td>
<td>DESIGN AND OPERATIONAL REQUIREMENTS</td>
</tr>
<tr>
<td>5.0</td>
<td>CONSTRUCTIONAL DETAILS</td>
</tr>
<tr>
<td>6.0</td>
<td>COMPONENT DETAILS</td>
</tr>
<tr>
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<td>OPTIONAL ITEMS</td>
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<td>8.0</td>
<td>PAINTING</td>
</tr>
<tr>
<td>9.0</td>
<td>TESTS AND INSPECTION</td>
</tr>
<tr>
<td>10.0</td>
<td>DRAWINGS AND DOCUMENTS</td>
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<tr>
<td>11.0</td>
<td>SPARES</td>
</tr>
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<td>12.0</td>
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</tr>
<tr>
<td>13.0</td>
<td>DEVIATIONS</td>
</tr>
<tr>
<td>ANNEXURE - I</td>
<td>DOCUMENTATION FOR UNINTERRUPTED POWER SUPPLY</td>
</tr>
<tr>
<td>ANNEXURE - II</td>
<td>METERING INDICATIONS AND ALARM SCHEDULE</td>
</tr>
</tbody>
</table>
1.0 SCOPE

1.1 The specification covers the design, manufacture, testing at works and despatch in well packed condition of Uninterrupted Power Supply System required to supply AC power for non linear loads (i.e. instrumentation loads).

1.2 This standard shall be read in conjunction with block diagram & UPS distribution diagram.

1.3 The scope shall include the following:
   i) Full wave controlled rectifier
   ii) Inverter
   iii) Static switches
   iv) Storage battery
   v) Static voltage stabilizer for bypass supply
   vi) Manual bypass switches
   vii) Isolation / output transformer to achieve desired output voltage
   viii) UPS Distribution Boards
   ix) Interconnecting cabling between various units of UPS
   x) All other items required, but not specified for safe and reliable operation of UPS system.

2.0 STANDARDS TO BE FOLLOWED

2.1 The equipment shall conform to the latest issue of the following and relevant Indian Standard specifications Equipment complying with equivalent IEC standards shall also be acceptable.

   IS-13314 - Solid state inverters run from storage batteries
   IS-11260 - Stabilized power supplies AC output
   IEC-146 - Solid state inverters

2.2 The equipment shall also conform to the provision of Indian Electricity Rules, Indian Supply Act and any other statutory regulations in force from time to time.

3.0 AMBIENT CONDITIONS & ELECTRICAL SYSTEM CHARACTERISTICS

These shall be as specified in the enclosed Design Philosophy - Electrical.

4.0 DESIGN AND OPERATIONAL REQUIREMENTS

4.1 The UPS unit and its associated equipments shall be suitable for operating at the specified rating continuously with the specified voltage and frequency variations under the ambient conditions without exceeding the temperature rise limits specified in relevant standards and without any detrimental effect on any part.

4.2 The UPS system shall be based on latest generation of IGBT based, pulse width modulated (PWM) design with proven performance. The basic scheme required for UPS system shall be as indicated in Block diagram in this specification.

4.3 The UPS shall have Redundant Scheme with Bypass. Under normal operating conditions, both inverter units should run in parallel sharing 50% load in synchronism with by-pass power and supply uninterrupted A.C. power to load. On failure of one of these inverters, the faulty inverter should get automatically disconnected from the load and healthy inverter should supply 100% load in synchronism with by pass supply. In
the event of second inverter also developing a fault, a no-break load transfer to standby power supply should take place through static switch.

4.4 Output frequency of the inverters must remain synchronised to one another which in turn shall be synchronised to the standby power supply frequency provided the latter does not vary by more than +3% to -5%. It should be possible to change the setting of frequency range of synchronism between above limits by frequency selector switch. Outside these limits inverter should desynchronise with the bypass and run at its own frequency. When running at its own frequency, frequency variation shall be maintained less than ±1.0%. Resynchronisation with bypass power supply must take place automatically with some time delay when frequency comes back to +3% to -5% range. Change-over from inverter to bypass or bypass to inverter shall also be possible in desynchronised mode of operation. Change-over time in both synchronised and desynchronised mode operation shall be indicated.

4.5 The UPS unit shall be suitable for 0.7 lagging to unity power factor. The overall power factor may be taken as 0.8 lagging.

4.6 The maximum waveform distortion of the output voltage shall not exceed 5% r.m.s. for linear loads and 10% r.m.s for non-linear loads. The UPS unit shall be suitable for operation for non-linear loads having crest factor of 3.

4.7 The inverter steady state output voltage and frequency (free running) variation shall not exceed ±1% for specified input power supply condition and no-load to full load condition.

4.8 Voltage dip / rise on sudden application / throw of 100% load or on changeover from inverter to bypass or vice versa shall not exceed 15% and shall be recovered within 100 m. sec. to rated voltage.

4.9 UPS shall be designed for overload of 125% for 10 min. and 150% for 10 sec. after which drooping characteristic shall come into operation.

4.10 On failure of the main supply, inverter unit shall continue to supply rated load from the battery bank for two hours duration.

4.11 Charger shall simultaneously supply entire power necessary for inverter and to keep the battery of required capacity in fully charged condition. Provision for automatic charging in both float and boost shall be made.

4.12 Battery shall be Nickel-Cadmium or Lead Acid Plate tubular positive plate or VRLA type. The battery capacity shall be decided considering load power factor as 0.8, derating factor for ageing 0.8 and derating for minimum ambient temperature as applicable.

4.13 The ventilation fans, if provided shall be fully redundant and connected to the output from the inverter and an audio-visual alarm shall be provided on its failure. It shall be possible to operate inverter for about half an hour even after the failure of the fan without temperature rise inside the inverter cubicle exceeding the safe operating temperature limits.

4.14 In case of inverter failure due to any reason or overload, affected unit shall be isolated and changeover to other inverter or to bypass shall take place automatically.

4.15 Noise level at a distance or 1m from UPS panels shall not exceed 60 dB.

4.16 UPS system shall be provided with necessary control, protection, metering, indication, alarm & annunciation for reliable and safe operation of the system. The suggestive list is indicated in Annexure-II.

4.17 All semi-conducting devices shall be protected by fast acting semi-conducting fuses. These fuses shall be co-ordinated with load side HRC fuses.
4.18 The battery may be taken out of service for maintenance during which period it shall be possible for the inverter to continue operation taking power from the rectifier. The input filter of the inverter shall be suitably designed to take care of this operational requirement.

4.19 It shall be possible to vary the output voltage steplessly within ±5% of the specified output voltage. This adjustment shall be possible to be made when UPS is in operation.

4.20 UPS system shall be suitable for both floating output and earthing of one leg in case of single phase system / star-point in case of three phase system.

4.21 The UPS system shall have very high system of reliability having minimum MTBF of 50,000 hrs. Vendor shall furnish the value of MTBF, MTTR & availability factor.

5.0 CONSTRUCTIONAL DETAILS

5.1 The equipment shall preferably be supplied in enclosed, dust & vermin proof, floor mounted, sheet steel enclosure. In case, it is necessary to provide opening for ventilation, this should be closed by fine mesh. Minimum degree of protection for enclosure shall be IP-43 as per IS/IEC-60947.

5.2 Enclosure shall be fabricated with cold rolled sheet annealed steel of minimum thickness 2.0 mm.

5.3 The door hinges shall be concealed type. The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets without any discontinuities. Gaskets shall be held in position in groove in shaped sheet steel work or these shall be of U type.

5.4 All external hardware shall be cadmium plated steel. Hardware for fixing the removable parts shall be provided with retaining devices.

5.5 Panels shall be liberally designed. All components shall be so mounted that they are easily accessible for inspection and maintenance.

5.6 UPS unit shall preferably have separate panels for each rectifier inverter units, bypass supply, distribution boards etc. Various panels of UPS except distribution boards shall be mounted side-by-side & bolted together to form compact assembly.

5.7 Distribution boards shall be of fixed type single front execution in fully compartmentalised design and divided into distinct panels each comprising of bus-bar chambers, individual feeder modules and vertical cable alley.

5.8 Mounting height of components requiring operation and observations shall not be lower than 300 mm and higher than 1800 mm.

5.9 All the live parts which are accessible after opening the front cover / back cover shall be properly insulated or provided with insulating barrier to prevent accidental contact. Bus bars of distribution boards shall be PVC sleeved.

5.10 Nameplate consisting of black Perspex with white engraving shall be provided for each panel and for each equipment mounted on the front of the panel. Suitable label identification for each component mounted inside the panel shall also be provided.

5.11 All the wirings shall be properly laid and ferruled at both ends. PVC channels may be used for wiring. For control wiring, minimum 1.5 sq. mm copper conductor shall be used.

5.12 The power connections shall be made by PVC insulated flexible copper cables or taped copper / aluminium strip.

5.13 All power & control cables shall enter from the bottom.
5.14 Removable bolted aluminium gland plate, heavy duty compression type rolled aluminium cable glands, crimping type aluminium cable lugs for Al. cables and copper cable lugs for Cu. cables, pressure clamp / bolted type terminals etc. shall be provided for each incoming and outgoing cable.

5.15 Terminal blocks shall be grouped according to circuit functions and suitably numbered. 20% extra terminals shall be provided in the terminal block.

5.16 A suitably sized earth bus shall be provided at the bottom of panel with provision for earth connection at both ends to purchaser’s earth grid.

5.17 All panels shall be of same height so as to form a bank which shall give good aesthetic appearance.

6.0 COMPONENT DETAILS

6.1 All components shall conform to relevant IS / IEC standards and shall be of reputed make. Makes of all components shall be subject to owner’s / consultant’s approval.

6.2 Thyristors, diodes and transistors
The thyristors, diodes and transistors shall have adequate safety margins to withstand specified operating conditions. A factor of safety of minimum 4 shall be taken against voltage surges.

6.3 PCBs
All electronic control & monitoring printed circuit cards shall preferably be modular plug in type. Monitoring points shall be provided in each of the PCB, PCBs shall be firmly clamped in position so that vibration or long usage does not result in loose contacts. Failure of each PCB shall be indicated by visual alarm and indication. The visual fault diagnostic shall preferably indicate fault into various sections of the card.

6.4 Transformers and Chokes
All transformers and chokes shall be of dry type and air cooled. This shall be class ‘H’ insulated, vacuum impregnated. Class B insulated cast resin transformers and chokes shall be also acceptable.

6.5 Electrolytic Capacitors
These shall be polarised aluminium type I, suitable for long life and category I, as per IS-4317 or equivalent IEC. The capacitor shall preferably be self healing type. These shall be so located in inverter panels that the operating temperature does not exceed 65ºC maximum.

6.6 Instruments
Ammeters & voltmeters shall be moving coil type of class 1.5 accuracy as per IS-1248. These shall be flush mounting type of minimum size of 96 mm x 96 mm and shall have taut band scale of 240º. Frequency meter shall be of reed type having range of 45 Hz to 55 Hz.

6.7 Static Switches
Static switches shall be naturally commutated type with parallel inverse connected thyristors. These shall be rated for continuous duty for 100% load. Short time rated static switches are not acceptable.

6.8 Voltage Stabilizer
Voltage stabilizer shall be static type and shall satisfy the following requirements:

i) Maximum output voltage variation under steady state condition shall be ±3%.

ii) Maximum harmonic distortion shall be less than 5%.

iii) The output voltage shall be restored within ±2% of nominal value in less than 2 secs.
6.9 **Battery**
Battery along with accessories shall conform to Engineering Standard ES-0814.

6.10 **Indication Lamps**
All indication lamps shall be of LED type suitable for the specified control voltage, having minimum illumination of 40 milli candela. The colour of the LEDs shall be as follows:

- **ON**: Red
- **OFF**: Green
- **FAULT**: Yellow

6.11 **Moulded Case Circuit Breakers**
For isolating devices of various equipment, moulded case circuit breakers shall be used. These shall be provided with overload and short circuit protective devices and shall conform to IS 2516.

7.0 **OTHER ITEMS**

7.1.1 **Monitoring System**
Microprocessor based monitoring system for UPS to supervise the UPS operation and to print out the following data at a preset time automatically by using its own printer shall be provided.

i) Output voltage of UPS (Common)
ii) Output current of UPS (Common)
iii) Input DC voltage of each inverter
iv) Input voltage of each rectifier (Ph to Ph)
v) Input current of each rectifier
vi) Output current of each inverter
vii) Output voltage of each inverter
viii) Room temperature
ix) Input frequency of each inverter
x) Output frequency of each inverter

7.1.2 In addition to print out once in a preset time, above data shall also be automatically printed for the following conditions:

i) Power source change over from mains to battery and vice-versa.
ii) Change over of load from UPS to bypass supply and vice versa.
iii) On failure of UPS
iv) On failure of either inverter
v) Also facility for on demand print out of above data shall be provided.

7.1.3 On failure of UPS, the printer shall print out the waveform of the following:

i) Output voltage of UPS
ii) Output current of UPS
iii) Output voltage of each UPS
iv) Output current of each UPS
7.2 **Insulation monitoring & automatic earth fault finding system**

Insulation monitoring and automatic earth fault finding system shall be provided to detect earth fault in unearthed system. The system shall preferably be of the type which injects a low frequency alternating voltage between the earth and the network which is used for determining the insulation resistance and to detect and locate earth faults. There shall be fixed detectors located in incoming feeders of main distribution boards and portable detector for location of fault within a feeder. The fixed detector shall be connected to a central unit which can display a faulty feeder.

7.3 Potential free contact shall be brought to outgoing terminal for remote monitoring system for the following:
   i) UPS-1 fault
   ii) UPS-2 fault
   iii) Load on inverter
   iv) Load on bypass

8.0 **PAINTING**

8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.

8.2 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.3 Unless otherwise specified, the finishing shade shall be light grey shade no.631 as per IS: 5.

8.4 Electrostatic powder paint shall be preferred.

9.0 **TESTS AND INSPECTION**

9.1 The UPS units shall be subjected to tests as per relevant standards. The tests shall include, but not limited to the following:-
   i) Rectifier & inverter soft starting
   ii) Regulation test
   iii) Heat run test for 8 hours
   iv) Overload test
   v) Test for changeover time in synchronised and desynchronised mode.
   vi) Test for dynamic response and transient performance
   vii) Sequence & transfer test
   viii) Noise level measurement
   ix) Test to check the selectivity of protective devices
   x) Alarm test (simulation of various fault conditions)
   xi) Measurement of harmonic distortion
   xii) Ventilation test (operation without fan)
   xiii) Insulation test
   xiv) Current division in parallel UPS
9.2 All the above tests shall be carried out in presence of purchaser’s representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.

9.3 These inspections, shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following description written boldly.
   - Name of client
   - Name of consultant
   - Enquiry / order number with plant / project name
   - Equipment Code no. & Description

11.0 SPARES

11.1 Spares for operation and maintenance
   Item wise unit prices of spare parts shall be quoted.

11.2 Commissioning Spares
   Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipments.

12.0 PACKING

12.1 The board shall be properly packed before despatch to avoid damage during transport, storage and handling.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
## ANNEXURE - I

**DOCUMENTATION FOR UNINTERRUPTED POWER SUPPLY**

<table>
<thead>
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<th>Sl. No.</th>
<th>Description</th>
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<td>5.</td>
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<tr>
<td>6.</td>
<td>Feeder Details for Distribution Boards</td>
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<tr>
<td>7.</td>
<td>Descriptive literature and catalogues</td>
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<td>9.</td>
<td>Schematic &amp; Wiring Diagram</td>
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<tr>
<td>10.</td>
<td>Installation, operation &amp; maintenance manual</td>
<td>N</td>
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<tr>
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<td>Spare parts list with identification</td>
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<td>12.</td>
<td>Test Certificates</td>
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<tr>
<td>13.</td>
<td>Guarantee certificates</td>
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</tbody>
</table>

### Note:

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N – No
ANNEXURE – II

METERING INDICATIONS AND ALARM SCHEDULE

A. METERING

1. Incoming Voltmeter with selector switches for each incomer
2. Ammeter with selector switches for each incomer
3. Ammeter & Voltmeter at each inverter output and bypass output.
4. Frequency meter & power factor meter at one common point of output
5. Ammeter & Voltmeter at incoming of each UPS distribution boards
6. Ammeter at each rectifier output
7. Battery charge / discharge meter

B. LED INDICATION

1. A.C. Mains ‘ON’
2. Rectifier output ‘ON’
3. Load on inverter
4. Load on bypass
5. Inverter synchronised to mains
6. Battery on float
7. Battery on boost
8. Fault (one lamp for all types of fault)

C. AUDIO-VISUAL ALARM (with Accept, Reset & Test facilities)

1. Mains failure
2. Rectifier failure
3. Inverter output over voltage
4. Inverter output under voltage
5. Inverter fuse failure
6. Rectifier fuse failure
7. Fan failure
8. Inverter temperature high
9. Static switch failure
10. Bypass input failure
11. Inverter desynchronised
TECHNICAL SPECIFICATION
POWER TRANSFORMERS
# CONTENTS

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1.0 **SCOPE**

1.1 This standard covers the technical requirements of design, manufacture, testing at works and despatch in well-packed condition of Power Transformers.

1.2 This standard shall be applicable for 3 phase, core type, separate winding power transformers of rating 315 KVA and above.

1.3 This standard shall be read in conjunction with the relevant part of Design Philosophy – Electrical.

2.0 **STANDARDS TO BE FOLLOWED**

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS 2026, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment offered shall comply with the provisions of the latest issue of the Indian Electricity Rules and other relevant Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 **SERVICE CONDITIONS**

3.1 **Ambient Conditions**

These shall be as indicated in Design Philosophy – Electrical.

3.2 **System Details**

These shall be as indicated in Design Philosophy – Electrical.

4.0 **OPERATING REQUIREMENTS**

4.1 The transformer shall be suitable for operating at the rated capacity continuously at any of the taps, under the ambient conditions and with the voltage and frequency variations without exceeding the permissible temperature rise and without any detrimental effect on any part.

4.2 The transformer shall also be capable of delivering rated current at a voltage equal to 105% of the rated voltage.

4.3 The transformer shall be capable of allowing at least three consecutive starts of the largest Squirrel Cage Induction Motor, while delivering 85% of its rated power without any harmful effect on its insulation. It shall be possible to repeat the starting cycle once in eight hours.

4.4 The transformer shall be designed to be loaded as per IS 6600.

4.5 The transformer shall be so designed as to operate in parallel satisfactorily with similar transformers.

5.0 **GENERAL DESIGN FEATURES**
5.1 The design of the transformers shall be in accordance with the latest practice.

5.2 **Rated Voltage, Frequency and Phase Connection**

These shall be as indicated in Design Philosophy – Electrical.

5.3 The transformer shall be so designed that it is capable of operation at 125% rated voltage for a period of one minute and 140% rated voltage for a period of five seconds due to sudden load throw off.

5.4 **Tap Changing Gear**

5.4.1 Each transformer shall be provided with on-load/ off-circuit tap changing equipment on the high voltage winding with taps. It shall be mounted on one side, in an easily accessible position.

5.4.2 The range of tap changer shall be as indicated and arranged in steps of 2.5%.

5.4.3 The off-circuit tap changing shall be affected by an externally operated handle capable of being padlocked in any position and provided with tap position indicator and mechanical stops at the extreme positions.

5.4.4 For transformer specified with on-load tap changer, tap changing gear shall be complete with tap position indicator, limit switch, lock and key and necessary control panel. Provision shall be made for auto-manual operation. The manual operation shall be possible both from the panel as well as from field. In case the tap changer is located in a separate housing, the housing shall be connected with the conservator for oil connection. A separate buchholz relay shall be provided in such a case. Emergency mechanical manual device shall also be provided. A minimum of 2 lakh trouble-free operations shall be guaranteed.

5.4.5 **ON-LOAD TAP-CHANGING MECHANISM (O.L.T.C.)**

5.4.5.1 For transformer specified with on-load tap changer, high speed tap changing gear shall be complete with tap position indicator, limit switch, lock and key and necessary control panel. Provision shall be made for auto-manual operation. In case the tap changer is located in a separate housing, the housing shall be connected with the conservator for oil connection. A separate buchholz relay shall be provided in such a case. Emergency mechanical manual device shall also be provided. A minimum of 2 lakh trouble-free operations shall be guaranteed. The OLTC gear shall have diverter resistance and the current diverting contacts shall be housed in a separate oil chamber segregated from the main tank of the transformer.

5.4.5.2 Transformer shall be provided with an on-load tap changing mechanism, as required. This shall be designed suitable for remote control operation from switch boards in the control room in addition to being capable of local manual as well as local electrical operation.

5.4.5.3 It shall not be possible to use the electric drive when manual gear is in use and it shall be possible to use only one electrical control at a time. Operation of the local or remote control switches shall cause one tap movement only until the control switch is returned to the off position for the next operation.

5.4.5.4 The local electrical control switches shall be mounted in the out door cubicle.

5.4.5.5 The equipment shall be so arranged as to ensure that when a tap change operation has been commenced it shall be completed independently of the operation of the control relays and switches. If a failure of the auxiliary supply during a tap change or
any other contingency result in that movement not being completed, adequate means shall be provided to safeguard the transformer and its auxiliary equipment from damage. Supervisory indication shall be provided to indicate “The change incomplete” foul.

5.4.5.6 Limit switches may be connected in the control circuit of the operation motor provided that a mechanical de-clutching mechanism is incorporated. Otherwise it shall be directly connected to the operating motor circuit and mechanical stop provided.

5.4.5.7 Thermal devices or other means shall be provided to protect the motor and control circuits. All relays switches, fuses etc. shall be mounted in the marshalling box and shall be clearly marked to indicate their purpose.

5.4.5.8 The whole of the apparatus shall be of robust design and capable of giving satisfactory service without undue maintenance under the conditions to be met in service, including frequent operation.

5.4.5.9 A five-digit counter shall be fitted to the tap changing mechanism to indicate the number of operations completed by the equipment.

5.4.5.10 A permanently legible lubrication chart shall be fitted within the driving mechanism chamber.

5.4.5.11 The ON-LOAD Tap Changer shall include the following :-

a) An oil immersed tap selector and arcing switch or arc-suppressing tap selector, provided with resistor for reduction of make and break arcing voltage, overload and short circuits.

b) Motor driven mechanism.

c) Control and Protection devices.

d) Local and remote tap-changer position indicator.

e) Manual operating device.

5.4.5.12 The on-load tap changer shall be designed so that the contacts shall not interrupt arc within the main tank of the transformer. The tap selector and arcing switch or arc suppressing tap selector switch shall be located in one oil filled compartment. The compartment shall be provided with a means of releasing the gas produced by the arcing. It shall be designed so as to prevent the oil in the tap selector compartment from mixing with the oil in the transformer tank.

5.4.5.13 The oil in those compartments of the main tap-changing apparatus which do not contain contacts used for making or breaking current shall be maintained under conservator head by means of an adequate diameter pipe corresponding dia of OLTC oil surge relays connection from the highest point of the chamber connection corresponding to the dia. of OLTC oil surge relay from the highest point of the chamber to the conservator. This connection shall be controlled by a suitable valve and shall be arranged so that any gas leaving the chamber will pass into the gas and oil actuated relay.

5.4.5.14 The tap changer shall be capable of permitting parallel operation with other transformers for which necessary wiring and accessories, if any, shall be provided.

5.4.5.15 The centre of manual operating device shall be located at a height of 1500 mm from rail top so that it can be operated by a person standing at the ground level. The arrangement shall be strong and robust in construction. The transformer shall give full load output on all tap positions.
The mechanism shall be complete with normal accessories including at least the following:

- A mechanical tap position indicator (Rated tap voltages shall be marked on the diagram plate).
- A mechanical operation counter.
- Mechanical stops to prevent over cranking of the mechanism beyond extreme tap positions.

5.4.5.16 The control scheme for the tap changer shall be provided for independent control of the tap changers when the transformers are in independent service. In addition, provision shall be made to enable parallel operation control also at time so that the tap changer will be operated simultaneously when one unit is in parallel with another will not become out of step and this will eliminate circulating current.

Additional features like Master / Follower and visual indication during the operation of motor shall also be incorporated.

Control circuit shall incorporate the following:

a) Local/remote manual electrical operation.

b) Device to ensure a positive and full completion of tap change once it is initiated even if there is loss of power.

c) An interlock to cut-off electrical control automatically upon recourse being taken to manual mechanical control in emergency.

d) Electrical interlock to cut-off a counter impulse for a reverse tap change, being initiated during a progressive tap change and until the mechanism comes to rest and resets circuits for a fresh operation.

e) All auxiliaries and devices for electrical control of OLTC gear should be housed in a weather-proof cabinet mounted on the transformer and shall include:
   - Local tap position indicator
   - 5 digit operation counter
   - Cubicle lighting
   - Thermostatically controlled space heater.
   - Miniature circuit breaker with magnetic and thermal overload devices for controlling the incoming supply to the OLTC motor.
   - Padlocking arrangement for the hinged cabinet door.
   - Removable plate with cable glands.
   - Inside tag with control scheme indelibly marked.

5.4.5.17 Necessary interlock, blocking independent control when the units are in parallel, shall be provided.

5.4.5.18 Under abnormal conditions such as may occur if the contactor controlling one tap changer sticks, the arrangement must be such as to switch off supply to the motor so that an out of step condition is limited to one tap difference between the units. Details of out of step protection provided for the taps should be furnished in the bid.

5.4.5.19 The contactor and associated gear for the tap change driving motors shall be housed in a local kiosk mounted adjacent to the transformer. The motors shall be suitable for operation on 230 V single phase or 3-phase 440 V, 50 cycle external power supply. The kiosk having space heater, shall be dust and vermin proof and suitable protected against corrosion or deterioration due to condensation, fungi etc.

5.4.5.20 Indoor cubicle (RTCC panel) shall be provided in the control room which shall contain:
a) Indication of the transformer ratio in use on each transformer and the number designsating the tap in use by means of digital type indicators.
b) Raise and lower push Button switch and AVR Relay.
c) Independent/Master/Follower selector switch.
d) Remote tap position indicator with indicating lamp.
e) Repeater dial of winding temperature indicator for remote indication with a device for indicating hottest spot winding temperature in addition to a pointer to register the highest temperature reached.
f) An indication lamp showing tap change in progress.
g) Necessary audible and visual alarms.
h) Pressure relief device operation alarm.
i) Out of step relay with two spare contacts (2 NC and 2 NO).
j) The remote indoor cubicle in addition to the above indications shall also have the following trip and non-trip alarm windows facias with 5 spare windows suitable for 110V DC supply.
   i) Oil Temperature alarm
   ii) Winding Temperature alarm
   iii) Winding temperature trip
   iv) Buchholz alarm
   v) Buchholz trip
   vi) Sudden Pressure trip (Main tank)
vii) Surge Relay trip (OLTC Gear)
viii) Tap changer out of step alarm
   ix) Low oil level alarm
   x) Cooling fans working indication
   xi) Oil pumps on and off indication
   xii) Failure of group of fans alarm
   xiii) Failure of group of oil pumps alarm
   xiv) Failure of supply
   xv) Oil flow alarm

Each relay for tripping function shall have two normally open and two normally closed contacts for connection.

5.4.5.21 The OLTC shall be provided on the conservator side of the Power Transformer and not in front of H.V. Bushings.

5.4.5.22 OLTC shall be suitable for bi-directional power flow.

5.5 Impedance Voltage

The impedance voltage of the transformer at 75°C shall be as per relevant IS / IEC. This shall be guaranteed within limits specified in relevant IS / IEC at principal tap position.

5.6 Losses

The losses under the full load condition, at the rated voltage and frequency shall be indicated by the vendor at 75°C. These shall be guaranteed within the tolerable limits specified in IS: 2026 at principal tap position. The purchaser has the right to impose penalty charges or reject the transformer in case of any difference in the test and guaranteed values.

5.7 Temperature Rise

The temperature rise of the winding, oil and core shall not exceed the values specified in IS: 2026 when the transformer is delivering its rated output continuously under the service conditions.
5.8 **Insulation Level**

All windings up to maximum system voltage of 72 KV shall have uniform insulation to earth. For windings having higher maximum system voltage, graded insulation is acceptable.

5.9 **Terminal Arrangements**

The HV and LV side terminal arrangement shall be provided as required. Disconnecting link chambers shall be provided on the transformer primary side in all cases as well as on secondary side, except where the termination is through bus duct. The disconnecting chambers shall be oil filled, preferably connected with the main tank through an isolating valve and also provided with a drain valve. However for system not exceeding 11 KV, air filled disconnecting chamber may be accepted. Suitable cable end box complete with cable glands and lugs shall be provided for termination of cables. Gland plate for single core cables shall be non-magnetic.

5.10 The transformer shall be able to withstand the electro-dynamic and thermal stresses due to terminal short circuit of the secondary, assuming the primary side fed from an infinite bus. All leads and windings in cores shall be properly supported, clamped and tightened after vacuum drying to ensure the short circuit withstand capacity. The short circuit withstand duration shall be 3 Secs.

5.11 The short circuit test results for similar transformers shall be furnished.

5.12 The transformer shall be so designed as to minimise any undue noise and vibration.

The noise level shall be limited to the value specified by latest NEMA Standard / CBIP.

5.13 Due attention shall be given in the design for the suppression of harmonics.

5.14 **Cooling System**

5.14.1 The cooling system shall be provided as required. In case the transformer is designed for two types of cooling, the output rating for each type shall be indicated in the offer. The minimum acceptable output shall be 70% of rated output when forced type of cooling system is not in operation.

5.14.2 Wherever ONAF Cooling is specified, the cooling fans shall be adequately rated and shall be suitable for auto/manual and local/remote operation. Auto operation shall be through winding temperature indicator contact.

5.14.3 Transformer shall have multiple cooling units with standby cooling units.

5.14.4 Cooling fans for each radiator bank shall be housed in fan box to prevent ingress of rain water. Each fan shall be suitably protected by galvanized wire mesh guard. It shall be possible to remove the cooling fan with motors without disturbing and dismantling the cooler structural frame work.

5.14.5 Where OFAF cooling is applicable, two numbers of centrifugal oil pumps shall be used. Measures shall be taken to prevent mal-operation of Buchholz relay or sudden pressure relay when all oil pumps are simultaneously put into service. The pumps shall be so designed that on failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil.

5.14.6 Cooling fans and oil pump motors shall be of squirrel cage, totally enclosed whether proof type suitable for operation on 400 volts, three phase, 50 Hz power supply. All motors having ball and roller bearings and grease lubricators shall be fitted with hexagonal nipples conforming to relevant Indian Standard.
5.14.7 An oil flow indicator with alarm contacts shall be provided for the confirmation of the oil pump operating in a normal state. An indication shall be provided on the control panel to indicate that the pump is running.

5.14.8 The coolers and theirs accessories shall be hot dip galvanized or corrosive resistant painted.

5.14.9 The supporting arrangement for the cooler units or for radiator banks shall be in such a manner that the stresses if developed, shall not be transferred to the flanges of the butterfly valves.

5.14.10 The shut off valves shall be provided on the tank at each point of connection of cooler units radiators to the transformer tank. Removable blanking plates shall be provided to permit blanking off the oil connection to cooler radiators.

5.14.11 All valves shall be of gun metal or cast steel or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall be opened by turning counter clock-wise when facing the hand wheel.

5.14.12 Means shall be provided for pad locking of valves in the open and closed position.

5.14.13 Every valve shall be provided with indicator to show clearly the position of the valve whether open or closed.

5.14.14 All valves shall be provided with flanges having machined faces.

5.14.15 The drilling of valve flanges shall comply with the requirements of IS:3639.

5.14.16 CONTROL OF COOLER OPERATION

5.3.15.1 Each motor or group of motors shall be provided with an electrically operated contactor and with control gear of suitable design both for starting and stopping the motor manually and also automatically from the contacts on the winding temperature indicating device as specified. Additional terminal for remote manual electrical control of motors shall be provided. Overload and single phasing protection shall be provided. HRC fuses shall be provided for short circuit protection. This equipment shall be accommodated in the marshalling box. The power supply shall be adequately and properly fused.

5.3.15.2 Where small motors are connected in groups, the group protection shall be arranged so that it operates satisfactorily in the event of a fault occurring on a single motor.

5.3.15.3 Where fans and oil pumps are provided, the connection shall be arranged as to allow the motors or groups of motors to be started up and shutdown either collectively or individually.

5.3.15.4 All motor contactors and their associated apparatus shall be capable of holding in and operating satisfactorily and without over heating for a period of ten minutes if the supply voltage falls for that period, to 75% of normal value and at normal frequency. The motor contactors and associated apparatus shall be capable of normal operation with a supply voltage of 85 % of the normal value and at normal frequency.

5.3.15.5 All contacts and other parts which may require renewal, adjustment or inspection shall be readily accessible.
5.3.15.6 The control arrangements are to be so designed as to prevent the simultaneous starting of motors of total rating of more than 20 HP where such an eventually may arise, two step operation shall be preferred.

5.3.15.7 Alarm indication for failure of group of fans and oil pump shall be provided.

5.3.15.8 Alarm indication shall be provided to indicate failure of power supply.

5.3.15.9 Provision in the cooler control circuit may be made such that tripping of transformer breaker on Differential or Sudden Pressure should lead to supply disconnection to motor of the cooler pump.

6.0 CONSTRUCTIONAL FEATURES

6.1 Core

6.1.1 The transformer core shall be of high grade, non-ageing, electrical silicon cold rolled magnetic sheet steel of low hysteresis loss and high permeability. The maximum flux density in any part of the core and yoke at rated voltage and frequency shall not exceed 1.7 Tesla. The core structure shall be securely grounded to prevent electrostatic potential. Lifting eyes and lugs shall be provided on the limbs and coils assembly. Preferably no bolt shall be used in the cores. Clamping shall be done external to the limb. Bolts passing through the yoke, if any, shall be insulated for 2 KV for transformers rated up to 33 KV and 5 KV for higher voltage ratings.

6.1.2 The temperature of the core shall not exceed that permitted in IS.

6.2 Tank

6.2.1 The tank shall be made of good commercial grade low carbon steel plate of adequate thickness capable of withstanding stress not less than 0.40 kg/cm², properly welded and gusseted to ensure a rigid construction. It shall also be able to withstand normal transportation shocks without any deformation and shall be capable of withstanding following vacuum.

<table>
<thead>
<tr>
<th>Highest System Voltage</th>
<th>MVA Rating</th>
<th>Vacuum in mm of Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 72 KV</td>
<td>Up to 1.6</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>Above 1.6 to 20</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>Above 20</td>
<td>760</td>
</tr>
<tr>
<td>Above 72 KV</td>
<td>For all Ratings</td>
<td>760</td>
</tr>
</tbody>
</table>

6.2.2 For outdoor transformer, the top of the tank, the marshalling box and the headers of radiators, shall be of such a construction so as to prevent accumulation of water.

6.2.3 Guides shall be provided to facilitate tanking and untanking of the core with the coil assembly. The details of anchoring of core and coil assembly of the tank shall be furnished.

6.2.4 Radiators, where necessary, shall be provided on the tank to facilitate cooling. These shall be detachable type and shall be provided with isolating valves at ends, drain plug and air release plug. The radiators shall be fabricated out of minimum 1.25 mm thick seamless steel tubing or pressed sheet steel. For sizes up to 500 KVA, cooling tubes shall be acceptable.

6.2.5 Means for lifting and jacking of the transformer shall be provided.

6.3 Windings
6.3.1 Each coil shall be made out of paper insulated electrolytic grade copper conductor. Similar coils shall be interchangeable. Successive coils of a winding shall be connected by accessible joints and shall be brazed and finished smooth to prevent abrasive damage to insulation. There shall be no sharp bends in the connecting leads to prevent corona discharge. Aluminium foil wound transformer will also be acceptable.

6.3.2 The winding assembly shall be dried and impregnated in the vacuum with tested insulating oil. The insulation resistance and polarization index of the winding measured after impregnation shall be furnished in the test certificate.

6.3.3 For transformers rated 20 MVA and above vapour phase drying shall be adopted.

6.3.4 The magnitude of impulse surges transferred from HV to the LV winding by inductive and capacitive coupling shall be limited to a value below the rated impulse strength of the LV winding. The impulse voltage test results and surge distribution on windings for similar transformer shall be furnished.

6.4 Insulation Materials

6.4.1 Class ‘A’ insulating materials specified in IS 1271 shall be used. Paper insulation shall be new and free from punctures. Wood insulation, where used, shall be well seasoned and treated.

6.4.2 The mineral oil shall comply with IS: 335. 10% extra oil shall be supplied along with the transformer in non-returnable drums.

6.4.3 For the transformers required to be filled up with inert gas for transport purpose, the required amount of oil including 10% extra shall be supplied in non-returnable drums.

6.5 Bushing

The bushing insulator shall be rated for the maximum system voltage and shall comply with the requirements laid down in IS. The minimum current rating shall be 400 Amps. in case of overhead line connected transformers, the bushings shall be outdoor type having creepage distances of 31mm/kV and complete with arcing horns. In case of transformers connected with bus duct or cable, the bushings shall be enclosed in the terminal box. In either case, they shall be detachable from outside of the tank. The hardware shall be of tinned copper or nickel plated brass suitable to receive the conductors. Separate neutral bushings shall be provided for earthing the neutral, as required. All bushings shall be marked with the symbols corresponding to the connection diagram indicated in the diagram plate and in accordance with IS.

Bushing rated 52 KV class and above shall be oil impregnated paper condenser bushings. Bushing rated below 52KV voltage class shall be solid porcelain or oil communicating type.

7.0 FITTINGS

7.1 Fittings as listed in Annexure - I shall be provided. Any other fittings which may be necessary for the satisfactory operation of the transformer shall also be provided on each transformer.

7.2 All fittings shall conform to relevant Indian Standard Specifications.

7.3 Fittings such as conservator and associated pipes, explosion vent pipe etc. shall be designed to withstand vacuum as specified in Clause 6.2.1 against atmospheric pressure.

7.4 Fittings such as rating plate, dehydrating breather, off-circuit tapping switch, dial type thermometer etc. which need to be observed/ operated, shall be mounted at
7.5 All opening shall be provided with gasketted metallic covers for protection during transportation.

7.6 All valves shall be of globe/butterfly type provided with blanking plates. The valve body shall be made of either Carbon Steel with trim of 13 Cr. steel or gun metal.

7.7 The rating plate, the terminal diagram and terminal marking plates shall be made of Aluminium and shall contain relevant details as per IS 2026. The Code No. of equipment shall be marked on a separate plate.

7.8 All terminals shall be anti loosening type and complete with connectors of required size. The earthing terminals shall have identification marks.

7.9 **Winding Temperature Indicator**

Winding temperature indicator for measuring hot spot temperature of the winding shall comprise of current transformer image coil, temperature sensing element, capillary tube jacketed with PVC sleeve, 150 mm dia. local indicating instrument with two pairs of contacts one for alarm and other for trip and maximum point indicator capable of being reset by hand without tools.

7.10 **Oil Temperature Indicator**

Oil temperature indicator for measuring top oil temperature shall comprise of 150 mm dial type thermometer, thermometer pocket and capillary tube jacketed with PVC sleeve. Thermometer shall have two pairs of contacts, one for alarm and other for trip and maximum point indicator capable of being reset by hand without tools.

7.11 **Buchholz Relay**

The Buchholz relay as per IS 3637 shall be of double float type, provided with, two pairs of contacts, one for alarm and other for trip, facility for testing by injection of air by hand pump and with a cock for draining and venting of air. The relay shall be provided with shutoff valves on the conservator side as well as on the tank side.

7.12 The alarm and trip contacts of all protective devices shall be potential free and rated for 1 Amp at 110 V / 220 V D.C.

7.13 **Marshalling Box**

7.13.1 A marshalling box shall be provided to accommodate all auxiliary devices except those which are to be located directly on transformer or housed in a separate panel.

7.13.2 The marshalling box shall be dust, weather and vermin proof type made of sheet steel of not less than 2 mm thick. The box shall be rectangular in shape having sufficient space for easy termination of cables. The terminal block shall be pressure clamp type. 10% spare terminals shall be provided.

7.13.3 Suitable heavy duty double compression type rolled Aluminium cable glands for all incoming and outgoing cables shall be provided.

7.14 **Current Transformers**

The current transformers shall be provided and shall comply with IS 2705. The C.T. terminals shall be accessible through a weatherproof removable cover for the purpose
of testing etc. CT polarity shall be clearly marked. The C.T. for standby earth fault protection shall be 15 VA, 5P10. The C.T.'s for differential and restricted earth fault protection shall be of Class PS accuracy. The values of $V_k$ and Imag for these CTs shall be furnished at the order stage.

7.15 **Wiring**

All controls, indication and protective devices provided on the transformer shall be wired up to the terminal block inside the marshalling box, by means of stranded copper heat resistant PVC insulated armoured cable of 1.1 KV grade and size not less than 2.5 sq. mm. Wiring shall be properly fixed on cable tray with at least 100 mm clearance from the transformer body. Suitable identification mark shall be provided on all wires.

7.16 **All** bought out items shall be of reputed make to be approved by Consultant/Purchaser.

8.0 **NITROGEN INJECTION FIRE PREVENTION AND EXTINGUISHING SYSTEM**

8.1 Nitrogen Injection Fire Prevention and Extinguishing System shall be provided for fire protection of Transformer against fire due to an arc, during internal faults and external fires is for preventing tank explosion. The system design shall also conform to TAC/NFPA norms.

8.2 The system should comprise the following:

i. Fire Extinguishing Cubicle with base frame and containing, oil drain assembly, nitrogen cylinder, electric mechanical control unit for oil drain and nitrogen release detections necessary for monitoring system flanges on top panel for connecting pipe connections from transformer, panel lighting etc.

ii. Control Box for monitoring system operation, automatic control and remote operation, with alarms, indication light switches, push buttons, audio signal, suitable for tripping and signaling on 110V DC supply.

iii. Pre-stressed non-return valve (PNRV) working on transformer oil flow rate, with proximity switch for remote alarm indication and with visual position indicator.

iv. Required number of fire detectors rated for 1410C for heat sensing, each fitted with two number cable glands.

v. Signal box for terminating cable connections from PNRV and fire detectors.

vi. Pressure relief valve with limit switch.

8.3 The following arrangements are required to be made on the transformer Tank at the time of fabrication of the tank:

i. Oil drain opening with pipe, flange and manual gate valve at about 120mm below the top cover. Pipe size DN125 for 100 MVA and higher ratings.

ii. Nitrogen Injection openings with pipe size DN 25 with flange and manual gate valve on tank sides at about 100-200 mm from the bottom plate.

iii. Flanges having 4 Nos. 18 dia. holes with pcd as 155mm and dummy pipe on the conservator pipe between buchholz relay and conservator tank manual gate valve, for fixing PNRV.

iv. Fire detector brackets on top cover.

v. brackets for fixing signal box at a suitable location on top cover or tank size wall.

8.4 **ACTIVATION OF NIFPES:**
Mal-functioning of fire prevention / extinguishing systems is their major shortcoming which leads to interruption in power supply. The Contractor shall ensure that the chances of malfunctioning of NIFPES are practically nil. To achieve this objective, the Contractor shall work out their scheme of activating signals which, while preventing mal-operation, should not be to rigorous to make the operation of NIFPES impracticable in case of actual need. Transformer isolation shall be the mandatory pre-requisite for activation of the system in Automatic mode or Remote mode in the control room.

In addition, at least following electrical-signals shall be provided in series for activating NIFPES.

8.4.1 Auto Mode
a) For Prevention of Fire:
   i) Differential Relay Operation
   ii) Buchholz Relay parallel with Pressure Relief Valve or RPRR. (Rapid Pressure Release Relay)
   iii) Tripping of all concerned breakers is a prerequisite for initiation of system activation.

b) For Extinguishing Fire:
   i) Fire Detector
   ii) Buchholz Relay paralleled with Pressure Relief Valve or RPRR.
   iii) Tripping of all connected breakers is a prerequisite for initiation of system activation.

8.4.2 Manual Mode (Local/Remote): Tripping of all connected breakers is a pre-requisite for initiation of system activation.

8.4.3 Manual Mode (Mechanical): Tripping of all connected breakers is a pre-requisite for initiation of system activation.

8.5 General Description of NIFPES

8.5.1 Schematic of the System
NIFPES should be a stand alone dedicated system for oil filled. It should have a fire extinguishing FE) cubicle placed on a plinth at a distance of 6-10 mtrs. from the transformer. The F.E. cubicle may be connected to the transformer oil tank (near its top) and to the oil pit from its bottom through oil pipes with gate valves. The F.E. cubicle should house a pressurized nitrogen cylinder connected to the transformer oil tank (near its bottom). Cable connections are to be provided from signal box placed on the transformer to the control box in the control room and from control box to F.E. cubicle. Fire detectors placed at the top of transformer are to be connected in parallel to the signal box. The signal box may be connected to a pre-stressed non-return valve fitted between the conservator tank and Buchholz relay. Control box is also to be connected to relay panel is control room for system activation signals.

8.5.2 Operation
On receipt of all activating signals, drain of pre-determined quantity of oil commences thus removing high temp. top oil layer. Simultaneously nitrogen is injected under high pressure at a pre-fixed rate, string the oil thus bringing the temperature of top oil layer down. Nitrogen occupies the space created by oil drained out and acts as an insulating
layer between the tank oil & fire on top cover. Pre-stressed non return valve blocks oil flow form conservator tank, thus isolating it & preventing aggravation of fire.

8.5.3 System Components

Broadly, NIFPES shall consist of the following components. It is emphasized that all components, necessary for fast reliable & effective working of NIFPES shall be considered within the scope.

8.5.4 Fire Extinguishing Cubicle

It shall be made of 3mm thick steel sheet, painted dark red from inside & outside with hinged split doors fitted with high quality tamper proof lock. It shall be complete with the base frame and the following :-

- Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer
- Oil drain pipe with mechanical quick drain valve.
- Electro mechanical control equipment for oil drain and pre-determined regulated nitrogen release.
- Pressure monitoring switch for back-up protection for nitrogen release.
- Limit switches for monitoring of the system.
- Flanges on top panel for connecting oil drain and nitrogen injection pipes for transformer.
- Panel lighting (CFL Type)
- Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.

8.6 Control Box

Control Box for monitoring system operation, automatic control and remote operation, with following alarms indication, light switches, push buttons, audio signal, line fault detection suitable for tripping and signaling on 110V DC supply:

- System on
- PNRV open
- Oil drain valve closed
- Gas inlet valve closed
- PNRV closed
- Fire Detector Trip
- Buchholz Relay Trip
- Oil drain valve open
- Extinction in pressure
- Cylinder pressure low
- Differential relay trip
- PRV/RPRR trip
- Transformer trip
- System out of service
- Line fault free detector
- Line fault differential relay
- Line fault buchholz relay
- Line fault PRV
- Line fault transformer trip
- Line fault PNRV
- Auto/Manual/Off
- Extinction release on
- Extinction release off
- Lamp test
- Visual / Audio Alarm
- Visual / Audio alarm for DC supply fail

The signals marked (*) shall be in the topmost row of control box panel. The signals marked (^) shall follow next.

### 8.7 Pre-stressed Non Return Valve (PNRV)

PNRV is to be fitted in the conservator pipe line between conservator & Buchholz relay. It shall have the proximity switch for remote alarm, indication and with visual position indicator. The PNRV should be of the best quality because malfunction of PNRV shall be of serious consequence as its closing leads to stoppage of breathing of transformer.

### 8.8 Fire Detectors

The system shall be complete with adequate number of fire detectors fitted on the top of oil tank, OLTC/Off ckt. Tap changer rated for 1410C for heat sensing each fitted with two no. cable glands (water proof/weather proof).

### 8.9 Signal Box

It shall be fitted on the transformer for terminating cable connections from PNRV & fire detectors and for further connection to the control box.

### 8.10 Cables

Fire survival cables, able to withstand 7500C, 4 core x 1.5mm sq. for connection of fire detectors in parallel shall be used. Fire retardant low smoke (FRLS) cable 12 core x 1.5mm sq. for connection between transformer signal box/marshalling box to control box and control box to fire extinguishing cubicle shall be used.

Fire retardant low smoke (FRLS) cable 4 core x 1.5mm sq. for connection between control box to DC supply source and fire extinguishing cubicle to AC supply source, signal box marshalling box to prestressed non return valve connection on transformer shall be used.

### 8.11 Pipes

Pipes, complete with connections, flanges, bends, tees etc. shall be supplied alongwith the system.

### 8.12 Other items

a) Oil drain and nitrogen injection openings with gate valves on transformer tank at suitable locations

b) Flanges with dummy piece in conservator pipe between Buchholz relay and conservator tank for fixing PNRV.

c) Fire detector brackets on transformer top cover.
d) Spare potential free contacts for system activating signals i.e. differential relay, buchholz relay, pressure relief valve, transformer isolation (master trip relay).

e) Pipe connections between transformer to fire extinguishing cubicle and fire extinguishing cubicle to oil pit.

f) Cabling on transformer top cover for fire detectors to be connected in parallel and inter cabling between signal box to control box and control box to fire extinguishing cubicle

g) Mild steel oil tank with moisture proof coating with capacity as minimum 10% of total oil quantity of transformer, with water tight cover, to be place in the oil pit. This tank shall be provided with the manhole, air vent pipe through silica gel breather, drain valve and a spare gate valve at the top.

h) Gate valves on oil drain pipe & nitrogen injection pipe should be able to withstand full vacuum. A non-return valve shall also be fitted on nitrogen injection pipe between transformers & gate valve.

i) Pressure relief valve, wherever not fitted on the transformer.

j) The F.E. cubicle shall be painted with post office red colour (Shade 538 of IS-5). All the exposed parts i.e. pipes, supports, signal box etc. shall be painted with enameled paint.

8.13 Modification on the transformer

No modification on the transformer shall be allowed which affects its performance (i.e. efficiency, losses, heat dissipation ability etc.), safety, life etc. or its any other useful parameter. This requirement shall be of paramount importance and shall be followed.

However, in any case, performance of transformer should not be affected in any manner by having NIFPES system and the Contractor shall give an undertaking to this effect. All pipes should be washed/rinsed with transformer oil. If any damage is done to the transformer and/or any connected equipment during installation & commissioning full recovery therefore shall be effected from the Contractor.

It shall be solely the responsibility of Contractor/Sub-Contractor to install, carry out pre-commissioning tests & commission NIFPES at Ridge Valley indicated in this Specification, to the entire satisfaction of the Owner/Consultant..

8.14 Interlocks

It shall be ensured that once the NIFPES gets activated manually or in auto mode, all the connected breakers shall not close until the system is actually put in OFF mode. Also PNRV shall get closed only if all the connected breakers are open.

8.15 In general, following Fire Extinction period and other data shall be followed:

On commencement of Nitrogen Injection: Maximum 30 seconds

From the moment of system activation to complete cooling: Maximum 3 minutes

Fire detectors heat sensing temperature: 141°C

Heat sensing area: 800mm radius

Pre-stressed non return valve setting for Operation: minimum 60 ltr. Per minute

Capacity of Nitrogen cylinder: Minimum 68 litre water capacity And shall hold minimum 10 cubic Meter gas to 150
8.16 The following information in detail shall be provided:
   a) The maintenance and testing schedule for NIFPES.
   b) All the steps required to be undertaken for restarting the transformer and connected equipment after operation and mal-operation (if any) of the NIFPES.
   c) The process of venting nitrogen in case nitrogen pressure in the cylinder exceeds the stipulated maximum value.

9.0 PAINTING

9.1 The surface to be painted shall be shot or sand blasted to remove all dust, scale and foreign adhering matter. All traces of oil and greases should be removed by suitable treatment.

9.2 All steel surfaces in contact with insulating oil shall be painted with heat resistant oil insoluble insulating varnish.

9.3 All steel surfaces exposed to outside shall be painted with suitable anti-rust and anticorrosive paints. Epoxy paints shall be used.

9.4 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

9.5 Unless otherwise specified, the finishing shade shall be light grey Shade No. 631 as per IS 5.

9.6 1 litre of paint per transformer shall be supplied for touch up at Site.

10.0 TESTS AND INSPECTION

10.1 All transformers shall be routine tested as per IS 2026. Transformer oil shall be tested as per IS 335.

10.2 Additional tests, wherever specified, shall be carried out on one transformer of each rating.

10.3 All the above mentioned tests shall be carried out in the presence of Purchaser’s representative. In addition, the transformers shall be subject to stage inspection at works and inspection at site for final acceptance.

10.4 These inspections shall, however, not absolve the Vendor from their responsibility for making good any defect which may be noticed subsequently.

11.0 DRAWINGS AND DOCUMENTS

11.1 The drawings and documents as per Annexure-III shall be furnished, unless otherwise specified.
11.2 All drawings and documents shall have the following descriptions written boldly:
-- Name of Client
-- Name of Consultant
-- Enquiry / order number with plant / project name
-- Equipment Code No. and Description

11.3 The transformer shall be suitably packed to avoid damage in transit and shall be properly sealed so as to completely exclude oxygen and moisture from coming in contact with oil. Bushing shall be wrapped in straw ropes or similar material and complete transformer shall be packed in wooden crates.

11.4 The packing box shall contain a copy of the installation, operation and maintenance manual.

11.5 All loose pieces shall be separately wrapped in moisture resistant paper and marked with identification mark of the corresponding transformer.

12.0 SPARES

12.1 Spares for operation and maintenance

Item wise unit prices of spare parts shall be quoted.

12.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

12.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

12.4 All spare parts shall be identical to the parts used in the equipment.

13.0 PACKING

13.1 The transformer shall be suitably packed to avoid damage in transit and shall be properly sealed so as to completely exclude oxygen and moisture from coming in contact with oil. Bushing shall be wrapped in straw ropes or similar material and complete transformer shall be packed in wooden crates.

13.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

13.3 All loose pieces shall be separately wrapped in moisture resistant paper and marked with identification mark of the corresponding transformer.

14.0 DEVIATIONS

14.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
ANNEXURE - I

LIST OF FITTINGS

I. The fittings as given below shall be provided for all the ratings of transformers.

1. Oil Sampling Valve.
2. Filter valves with plug.
3. Radiator shutoff valves on top and bottom for each unit.
5. Winding temperature indicator for 1000 KVA and above.
6. Oil temperature indicator.
7. Oil level indicator with minimum marking.
8. Oil conservator complete with drain plug and oil filling hole with cover.
9. Buchholz relay with air release device and alarm and trip contacts.
10. Silica gel breather with oil seal and connecting pipe.
11. Explosion vent.
12. Bi-directional rollers.
13. Inspection holes with cover.
14. Marshalling Box.
15. Rating Plate.
17. Lifting lugs.
18. Jacking pad.
20. Air release device.
22. Ladder with safety device for access to the top of transformer tank.

II. The additional fittings as given below shall also be provided, as per requirement:

1. Magnetic oil level gauge with low oil level alarm contact.
2. Hauling lugs for extra high voltage transformers.
3. Protective CTs for
   a) Stand-by earth fault.
   b) Restricted earth fault.
   c) Differential protection.
4. Bi-directional wheels if already bi-directional rollers not considered.
5. Skids.
6. Cooler units complete with valves, fans, pumps, oil flow indicators, supporting structure with fixing and foundation bolts etc as required and Cooler Control panel.
7. Tap-changing gear complete with tap position indicator, operation counter etc. For OLTC gear(where specified), oil surge relay(OSL) with shut-off valve, Local control cabinet.
8. Nitrogen Injection Fire Prevention and Extinguishing System
### DOCUMENTATION FOR POWER TRANSFORMERS

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<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Documents Required (Y / N)</th>
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<td>With Bid</td>
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<tr>
<td>1.</td>
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<td>Technical Particulars</td>
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<td>3.</td>
<td>Dimensional drawing for complete Transformer, Marshalling Box, disconnecting</td>
<td>N</td>
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<tr>
<td></td>
<td>chamber, terminal chambers etc.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Schematic and Wiring Diagram</td>
<td>N</td>
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<tr>
<td>5.</td>
<td>Terminal arrangement drawing</td>
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<tr>
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<td>Installation, operation and maintenance manual</td>
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<td>7.</td>
<td>Catalogues and test certificates for bought out accessories</td>
<td>N</td>
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<td>Type test certificates of similar transformer</td>
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<tr>
<td>9.</td>
<td>Test Certificates</td>
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<td>Guarantee Certificates</td>
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<tr>
<td>11.</td>
<td>Spare parts list with identification marks</td>
<td>N</td>
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</tbody>
</table>

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
TECHNICAL SPECIFICATION

NEUTRAL EARTHING RESISTOR
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<td>ANNEXURE - I</td>
<td>DOCUMENTATION FOR NEUTRAL EARTHING RESISTORS</td>
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</table>
1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and despatch in well packed condition of Neutral Earthing Resistor for earthing the neutral of power transformers / generators for limiting the line to ground fault current.

1.2 This standard shall be read in conjunction with the relevant part of Design Philosophy – Electrical.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS 3043, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment shall also comply with the provisions of latest issue of the Indian Electricity Rules and other relevant Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy – Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy – Electrical.

4.0 OPERATING REQUIREMENTS

4.1 The neutral earthing resistor shall be suitable for carrying the rated current for duration of 30 seconds under the specified ambient conditions and voltage and frequency variations without the temperature exceeding 350ºC.

4.2 The resistor shall be designed to carry continuously 20% of the rated short time current without any harmful effect.

4.3 The housing shall be sized such that temperature rise of the metal parts through which current is not required to pass, when rated current is passed for the specified period, shall not exceed 40ºC.

5.0 GENERAL DESIGN AND CONTRUCTIONAL FEATURES

5.1 Resistors

5.1.1 The resistance bank shall be of heavy duty non-inductive type having high specific resistance and low temperature co-efficient.

5.1.2 The resistor elements shall be made of joint-less, non-corroding, sturdy and oxidation resistant AISI 304 / AISI 406 stainless steel of punched / formed construction.
5.1.3 The contact between elements shall be made by individually bolting the terminals of two adjacent elements and connecting them in series, parallel or combination of both to achieve the specified resistance. The interconnecting link shall be zinc plated copper of uniform cross section throughout.

5.1.4 The resistance grid shall be properly supported so that damage due to vibration and thermal or mechanical stresses is avoided.

5.1.5 Porcelain / Epoxy insulators rated for the highest system voltage shall be used to insulate the resistor elements from the body of the housing.

5.1.6 Insulation level for resistor bank shall be as follows:

<table>
<thead>
<tr>
<th>Highest system voltage</th>
<th>Power frequency withstand voltage</th>
<th>Impulse withstand Voltage</th>
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</thead>
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<tr>
<td>Up to 3.6 KV peak</td>
<td>10 KV RMS</td>
<td>40 KV</td>
</tr>
<tr>
<td>7.2 KV peak</td>
<td>20 KV RMS</td>
<td>60 KV</td>
</tr>
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5.2 Metal clad housing

5.2.1 The housing shall be fabricated out of 3 mm thick sheet steel fitted on a 6 mm thick mild steel frame work. This shall be floor mounting type and rectangular in shape.

5.2.2 It shall be suitable for outdoor installation and shall have minimum degree of protection IP: 43 as per IS 2147. Ventilating louvers, if provided, shall be covered by fine wire mesh from inside and shall be such that the above degree of protection for the enclosure is not altered. Top cover of the housing shall be slopping construction to prevent accumulation of water.

5.2.3 All external hardware below 8 mm size shall be of stainless steel and those of higher size of mild steel cadmium plated or zinc passivated.

5.3 Isolation Arrangement

5.3.1 An isolator shall be provided on the incoming side to isolate the resistors from the main equipment.

5.3.2 The isolating switch shall be single pole knife type having a rating of 1.5 times the rated current of the resistor. The switch shall have four sets of potential free auxiliary contacts, 2 NO and 2 NC for remote indication, wired to a terminal block. An external handle, suitably insulated and lockable both in the ON and OFF positions, shall be provided for the switch. The handle shall preferably be mounted at a height of 1.5 meters from the base of the housing.

5.4 Current Transformers

Epoxy moulded current transformer of accuracy 5P for stand by earth fault protection and PS for restricted earth fault protection shall be provided, as per requirement. The CT connections shall be brought to separate terminal box with shorting arrangement.

5.5 Terminal Arrangement

5.5.1 For incoming connection, either bushing or cable box arrangement shall be provided. In case of bushing connection, the bushing shall be provided on top of the housing. In case of cable box connection, the same shall be mounted on the side of the housing.

5.5.2 For the outgoing connection, cable box arrangement is to be considered in all cases. The cable box shall be mounted on the side of the housing.
5.5.3 Heavy duty double compression type rolled aluminium cable glands shall be provided for all the incoming and outgoing cables.

5.5.4 The equipment terminals shall be anti loosening type and complete with tinned copper cable lugs suitable for cables of specified size. For bushing connections, suitable tinned copper conductor shall be provided as per conductor size specified.

6.0 ACCESSORIES

6.1 The equipment shall be complete with cable glands, cable lugs, drain plug, lifting hook, name plate, foundation bolts and all other accessories required to make the equipment complete in all respects.

6.2 Name Plate

6.2.1 Name plate shall be of stainless steel with letters embossed on them.

6.2.2 The name plate shall contain all the required details and shall include at least the following:
   i) Make
   ii) Description of code no. of equipment
   iii) Short time rating
      a) Current
      b) Duration
   iv) Rated voltage
   v) Maximum temperature rise over ambient
   vi) Total resistance at ambient temp.
   vii) Materials of resistors
   viii) Degree of protection of enclosure

7.0 PAINTING

7.1 The enclosure, after suitable pre-treatment shall be painted with two coats of antirust paint followed by two coats of anti-corrosive paints.

7.2 Epoxy based paints shall be used.

7.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

7.4 The finishing paint shall be light grey shade no. 631 as per IS 5.

8.0 TESTS AND INSPECTION

8.1 Following tests shall be carried out on the neutral earthing resistors:

8.1.1 Routine Tests
   i) Resistance value measurement at room temperature.
   ii) Power frequency high voltage test for one minute.
   iii) Insulation resistance test.

8.1.2 Type test
   i) Heat run test.
8.2 The above mentioned tests shall be carried out in the presence of purchaser’s representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and inspection at site for final acceptance.

8.3 The purchaser’s inspection shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

9.0 DRAWINGS AND DOCUMENTS

9.1 The drawings and documents as per Annexure-I shall be furnished unless otherwise specified.

9.2 All drawings and documents shall have following descriptions written boldly.
- Name of the client
- Name of consultant
- Enquiry / order number with plant / project name
- Equipment code no. and Description.

10.0 SPARES

10.1 Spares for operation and maintenance
Item wise unit prices of spare parts shall be quoted.

10.2 Commissioning Spares
Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

10.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

10.4 All spare parts shall be identical to the parts used in the equipment.

11.0 PACKING

11.1 The neutral earthing resistor shall be properly packed to safeguard against weather conditions and handling. It shall be wrapped in polythene bag with an additional wrapping of bitumen paper to make it completely waterproof before the equipment is packed in wooden crates.

11.2 A sign to indicate the upright position of the panel for placing during transport and storage shall be clearly marked.

11.3 Packing box shall include one copy of the installation operation and maintenance manual

12.0 DEVIATIONS

12.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
# ANNEXURE - I

## DOCUMENTATION FOR NEUTRAL EARTHING RESISTORS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>With Bid</th>
<th>For Approval</th>
<th>Final</th>
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<tbody>
<tr>
<td>1.</td>
<td>Specification Sheet</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>2.</td>
<td>Technical Particulars</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<td>3.</td>
<td>General arrangement drawings</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<td>Illustrative and descriptive catalogues</td>
<td>N</td>
<td>N</td>
<td>Y</td>
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<td>5.</td>
<td>Installation, Operation and maintenance manual</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>6.</td>
<td>Test Certificates</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>7.</td>
<td>Guarantee Certificates</td>
<td>N</td>
<td>N</td>
<td>Y</td>
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</table>

### Note:

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
TECHNICAL SPECIFICATION

MEDIUM VOLTAGE SWITCH BOARDS
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</tbody>
</table>
1.0 **SCOPE**

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of Medium Voltage Switchboards.

1.2 This standard shall be applicable for the Power Control Centres, Power cum Motor Control Centres and Motor Control Centres.

1.3 This standard shall be read in conjunction with relevant part of Design Philosophy – Electrical, Schematic diagrams etc.

2.0 **STANDARDS TO BE FOLLOWED**

2.1 The design, manufacture and testing of the equipment shall comply with the latest issue of the following Indian Standards, unless otherwise Specified. Equipment complying with equivalent IEC standards shall also be acceptable.

   - IS 8623 - Specification for low voltage switchgear and control gear assemblies
   - IS/IEC 60947 - Low-voltage switchgear and control gear (General Rules)
   - IS 5578 - Guide for marking of insulated conductors
   - IS 10118 - Code of practice for selection, installation and maintenance of switchgear and control gear
   - IS 11353 - Guide for uniform system of marking and identification of conductors and apparatus terminals

   Various components housed in the switchboards shall conform to the Indian Standard specifications as mentioned against the component details or IEC specifications.

2.2 The design and operational features of all the equipment offered shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations, as applicable. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification / IEC Specification, the requirement specified herein shall prevail.

3.0 **SERVICE CONDITIONS**

3.1 **Ambient Conditions**

These shall be as indicated in Design Philosophy – Electrical.

3.2 **System Details**

These shall be as indicated in Design Philosophy – Electrical.

4.0 **OPERATING REQUIREMENTS**

The Medium Voltage Switchboards shall be suitable for operating at the specified rating continuously, with the specified voltage and frequency variations under the ambient
conditions, without exceeding the permissible temperature rise and without any detrimental effect on any part.

5.0 DESIGN AND CONSTRUCTIONAL FEATURES

5.1 General

5.1.1 The switchboards shall consist of an assembly of a series of floor mounting, identical, metal clad, dead front type sheet steel panels of unitized design. The panels shall be placed side by side to form a compact assembly and shall be extensible on either side.

5.1.2 The complete assembly shall be dust, damp and vermin proof having minimum degree of protection equivalent to IP-52 as per IS/IEC:60947.

5.1.3 The frame work of the cubicles shall be of bolted/welded construction. The minimum thickness of sheet steel shall be 2 mm for load bearing members, 1.6 mm for non-load bearing members and 3 mm for base channel. The doors and covers shall be fabricated from cold rolled sheets. Suitable reinforcement, wherever necessary, shall be provided.

5.1.4 The door hinges shall be concealed type.

5.1.5 All external hardwares shall be cadmium plated. The hardwares for fixing the removable parts shall be provided with retaining devices.

5.1.6 The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets. Gaskets without any discontinuity shall be preferred. Gaskets shall be held in position in groove, in shaped sheet steel work or these shall be of U type. Adhesive cement, if used, shall be of good quality so that the gaskets do not come off during service.

5.1.7 All the components shall be accessible for inspection and maintenance without the necessity for removal of the adjacent ones.

5.1.8 The layout of the component inside the module shall be liberal to facilitate maintenance and interconnecting wiring between the components shall not be subjected to any undue stresses at the bends.

5.1.9 Mounting height of components requiring operations and observation shall not be lower than 300 mm and higher than 1800 mm.

5.1.10 Inter panel barriers shall be provided.

5.1.11 All the live parts which are accessible after opening of front cover/cable alley cover/back cover shall be properly insulated or provided with insulating barrier to prevent accidental contact. Removal facility shall be provided for all such parts.

5.1.12 Adequate arrangement for earthing shall be provided to safeguard the operator or other personnel from electric hazards under all conditions of operation.

5.2 Panel Arrangement

The Switchboards shall be in fixed/draw out, single front execution, fully compartmentalised type and divided into distinct panels, each comprising of:

i) A completely metal enclosed bus-bars compartment running horizontally the top.
ii) Individual feeder modules.
iii) Enclosed vertical bus-bars serving all modules, in case of multi-tier panels.
iv) A vertical cable alley.
v) Separate horizontal enclosure for all auxiliary power and control buses.

5.3 Circuit Breaker Controlled Feeders
5.3.1 The panels housing circuit breaker feeders shall be in single front draw out execution. The incoming and bus coupler circuit breaker feeders shall be in single tier formation while the outgoing circuit breaker feeders may be in double tier formation.

5.3.2 A suitable barrier shall be provided between the circuit breaker and the associated control, protective and indication devices including instrument transformers.

5.3.3 All the protective relays and meters shall be flush mounted type. The relays and meters pertaining to a particular circuit breaker shall be mounted on the same panel. Where it is not possible to accommodate all the relays and meters in the same panel, one metering panel shall be provided adjacent to the circuit breaker panel exclusively for that feeder. Location of these in the adjacent panel of other feeders shall not be acceptable.

5.3.4 A spacious cable chamber suitable for accommodation, support and termination of required number of power cables shall be provided at the back. No bare bus-bars or live connection shall intrude into the cabling space.

5.3.5 The switchboard shall be provided with following inter locks and safety features:
   i) It shall not be possible to open the compartment door unless the breaker is drawn to isolated position.
   ii) The withdrawn and engagement of a circuit breaker shall not be possible unless it is in open position.
   iii) The operation of a circuit breaker shall not be possible unless it is in fully service, test or isolated position.
   iv) It shall not be possible to close the circuit breaker in service position unless all auxiliary and control circuits are connected.
   v) A breaker of the lower rating shall be prevented from engaging with the stationary element of higher rating.
   vi) Insertion of the manual mechanism shall render the motorised mechanism in operation.
   vii) Circuit breaker ‘ON’, ‘OFF’ indication shall be provided at the back of each panel. Alternatively, alarm shall be provided in case panel back door is opened with breaker “ON”.
   viii) Caution nameplate shall be provided at the back of incomer’s panels where terminals are likely to remain live and isolation is possible only from remote end.
   ix) Automatic safety shutter, with Padlocking facility for locking in closed position, to completely cover the spouts for the bus-bars and cable connection when the breaker is withdrawn.

5.4 Switch/MCCB Controlled Feeders

5.4.1 The panels housing motor starter or other feeders shall be either fixed or draw out type in single front execution.

5.4.2 All components of one feeder shall be mounted on a rigid sheet steel chassis.

5.4.3 Each panel shall be divided into a number of modules in tier formation placed one above the other. These modules shall be closed on all sides.

5.4.4 The modules shall be so placed that largest one is placed at the bottom of the panel. Type modules shall be at least 300 mm from the base channel.

5.4.5 The number of modules shall be so decided that the cables in the cable alley are not over crowded. However the number of module in any panel shall not exceed six.

5.4.6 The minimum size of module shall be 300 mm and 200 mm for starter and switch fuse feeders respectively.

5.4.7 The minimum clear width of cable alley shall be 250 mm.
5.4.8 For MCC rated above 630 Amp. The incomer and bus coupler modules shall be located in individual single panel. For MCC rated for 630 Amp. and below the incomer and bus coupler modules shall be half the panel size.

5.4.9 The module door shall be so interlocked that it shall not be possible to open the door with switch in closed position and close the door unless the module is fully plugged in. Defeat interlock facility shall be provided.

5.5 Special Features of Draw out Modules

5.5.1 The module shall be fully draw out type with sheet steel chassis moving freely on the guides. Chassis of the same size shall be fully interchangeable.

5.5.2 The module shall have the following distinct mechanical positions:
   i) Service -- In which both power and control contacts shall be made.
   ii) Test -- In which power contacts shall be isolated but control contacts shall be made.
   iii) Isolated -- In which both power and control contacts shall be Isolated.

   Maintenance position shall be preferred.

5.5.3 Each position shall be clearly marked. Padlocking facility shall be provided to padlock the chassis in any of the position.

5.5.4 The movement of the chassis from one position to the other shall be controlled by using an appropriate racking mechanism. Stopper shall be provided to prevent over travel of the chassis beyond the isolated position.

5.5.5 The guiding system shall permit smooth movement of the module and the power and control contacts shall be self-aligning type so that accurate alignment of the contacts is ensured.

5.5.6 No wiring shall be taken to the door. Only the actuators of the push buttons and switches, lenses for the indicating lamps and Perspex cover for meters shall be mounted on the door.

5.5.7 The power contacts shall be of plug-in/stab-in type made of silver plated copper, spring loaded and of adequate current carrying capacity. The contacts shall be so designed that contact pressure is maintained both under normal and short circuit conditions.

5.5.8 The parting contacts, both on bus-bar side and outgoing cable side, shall always be copper to copper and both sides silver plated. A bimetallic strip shall be used where two dissimilar materials are in contact.

5.6 Bus-Bars and Connections

5.6.1 The bus-bars shall be for three phase and neutral. The main bus-bars and connections shall be made of electrolytic grade copper of rectangular cross-section. Auxiliary bus-bars for control supply, space heater supply etc. shall be made of electrolytic copper.

5.6.2 The horizontal bus-bars shall be insulated with heat shrinkable PVC sleeves of reputed make to protect against approach to live parts. The vertical bus-bars shall be sleeved or shrouded by barriers. Removable type insulating shrouds shall be provided for all joints of horizontal bus-bars.

5.6.3 The bus-bars shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding temperature limits specified in IS: 8084. The thermal rating of the bus-bars shall be designed to withstand the system fault current for 1 second without exceeding the limiting temperature of 200ºC for bare Aluminium/Copper. Calculation for bus-bars sizing shall be furnished along with the offer.
5.6.4 Horizontal bus-bars shall be of the same cross-section throughout. Stepped bus-bars shall not be acceptable.

5.6.5 The bus-bars shall be arranged and colour coded according to IS: 5578 / IS: 11353.

5.6.6 The bus-bar chamber shall be sufficiently spacious and shall have separate screwed covers for maintenance purpose.

5.6.7 The bus-bars shall be rigidly supported at equal intervals to withstand maximum short circuit stresses. The supports shall be of moulded construction with built-in anti-tracking barriers. The support materials shall be of DMC or fibreglass reinforced thermosetting plastic.

5.6.8 Bus-bar joints shall be between the two transporting sections only.

5.6.9 A minimum of two bolts shall be used in bus-bar joints. Only high tensile electric galvanized bolts, nuts and washers shall be used.

5.6.10 In case of Aluminium bus-bars, all joints shall be suitably treated to avoid oxidation of contact surfaces and bimetallic corrosion.

5.7 Earth Bus

A continuous earth bus of electrolytic grade copper, running along the entire length of the lower part of the switchboard shall be provided with lugs at two ends for external connections. The minimum size of earth bus shall be suitable for carrying three phase fault current for 1 sec.

5.8 Bus Duct

5.8.1 Suitable extension of bus-bars in proper phase sequence on the top, with the connecting bolts shall be provided where connection of transformer to switchboard is specified to be through bus duct.

5.8.2 Bus duct between two halves of a switchboard, if required, shall be supplied by the switchboard manufacturer. The bus-bars of interconnecting bust duct shall be similar to the main bus-bars of the switchboard and as specified above.

5.8.3 Bust duct between transformer and incoming breaker panel, if included in Vendor’s scope, shall conform to ES-8062.

5.9 Clearances and Creepage Distances

5.9.1 The clearances and creepage distances shall not be lower than the values specified below:

i) Minimum clearance between two live conductors -- 20 mm

ii) Minimum clearance between live parts and accidentally dangerous part -- 20 mm

iii) Minimum creepage distance -- 28 mm

5.9.2 The clearances and creepage, as specified above, shall definitely be maintained in the bus-bar system. Provision of bus-bar insulation, separators or barriers shall not be considered to reduce the clearance from the values specified above.

5.9.3 At the termination points in the equipment e.g. switches, contactors, thermal relays etc. It is realized that above clearances may not always be possible to be maintained. All such points, where above clearances and creepage distances are not possible to be maintained, shall be insulated or taped.

5.10 Insulation
5.10.1 The insulation used shall be non-hygroscopic and may be of porcelain, epoxy resins or fibreglass moulded with plastic. It shall be of adequate electrical, mechanical and thermal strength to give trouble free service during normal operation and short circuit conditions.

5.10.2 The insulation shall be treated suitably to withstand the tropical conditions and atmospheric pollution.

5.11 **Power Wiring**

5.11.1 The connections from bus-bar to individual functional unit on the modules shall be of PVC insulated flexible copper cables or taped Copper/Aluminium strip.

5.11.2 The power wiring size shall be decided based on rating of the switch/breaker after using a rating factor of not more than 50% over the current rating in free air.

5.11.3 Power wiring size selected for breaker controlled module shall also be able to withstand full short circuit current for duration of 0.25 sec.

5.11.4 In any case minimum size of power wiring shall not be less than 4 sq. mm copper.

5.11.5 The size of connection from incomer to horizontal bus-bar and from horizontal bus-bar to bus-coupler shall not be less than the size adopted for horizontal bus-bar.

5.12 **Control Wiring**

5.12.1 The switchboard shall be completely factory wired and ready for external connections.

5.12.2 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables of 1100 Volt grade. The size of wires shall be as follows:

- C.T. Circuit -- 2.5 sq. mm
- V.T. and Control Circuits -- 1.5 sq. mm

5.12.3 All wiring shall be provided with dependent both ends marking as per IS: 5578. Numbered ferrules, reading from the terminals outwards, shall be provided at both ends of all wiring for easy identification. These shall be interlocking type plastic ferrules.

5.12.4 Control wiring circuits, fed from a supply common to a number of panels, shall be so protected that failure of a circuit in one panel does not effect the operation of the other panels.

5.12.5 The wiring to the equipment mounted on the doors shall be carried out with flexible multi strand copper conductor cable and so supported that on opening of the door there is no undue strain on wire leads.

5.12.6 The control cables shall be neatly arranged and properly supported.

5.13 **External Cable Termination**

5.13.1 All power and control cables shall enter the switchboard from the bottom. Sufficient space shall be provided for ease of connection and termination of cables.

5.13.2 The type, number and sizes of cables shall be as indicated in Feeder details.

5.13.3 Compression type cable glands along with the cable lugs as required shall be provided for termination of cables.

5.13.4 The cable glands shall be of rolled Aluminium heavy duty double compression type and shall be mounted on a removable gland plate, provided at a minimum height of 75 mm from the bottom of the switchboard. Two number spare knockouts of size 20 mm shall also be provided on the gland plates for future use. Gland for termination of single core cables shall be nonmagnetic type.
5.13.5 For all power cables, crimped type Aluminium lugs for Aluminium cables and tinned Copper lugs for Copper cables shall be provided.

5.13.6 The terminal blocks shall be pressure clamp type up to 35 sq. mm cable sizes and bolted lug type for higher sizes of cables. These shall be protected type and rated for 1100 Volts service. The minimum current rating of terminal block shall be 16 Amp. The construction shall be such that after the connection of cables by means of lugs, necessary clearance and creepage distance are available.

5.13.7 Where more than two cables in parallel are required to be terminated, a system of bus links shall be provided with adequate clearance and spacing.

5.13.8 Suitable clamps to support the vertical run of cables shall be provided.

5.13.9 The terminal block shall be grouped according to circuit functions and suitably numbered. 20% extra terminals shall be provided in the terminal block.

5.13.10 For power connections, suitable marking on the terminals shall be provided to identify the phases.

5.14 Feeder Details

5.14.1 The requirements of incomer, bus coupler and outgoing feeders shall be as indicated in the single line diagram, feeder details and corresponding schematic diagrams.

5.14.2 Interlocks shall be provided between incomers and bus section panels. The interlocks shall be either electrical or mechanical type. In addition, arrangement for defeating the interlock shall also be provided to facilitate manual changeover.

5.14.3 Auto changeover scheme, wherever specified, shall be provided.

5.15 Dummy Panels

Dummy panels complete with bus-bar system in 400 mm width may be required for which unit price shall be indicated.

5.16 Control Power Supply

5.16.1 D.C. Power required for closing, tripping and indication of circuit breaker feeders shall be supplied at the bus coupler panel through two completely separate circuits by owner, one for tripping and other for closing and indication.

5.16.2 For receiving each external control supply, a double pole miniature circuit breaker shall be provided. This power shall be distributed inside the switchboard for each circuit breaker feeder having its MCB unit.

5.17 Space Heater Power Supply

5.17.1 Panel space heater shall be fed from a separate bus common for the whole board. This bus shall be fed from owner's supply for which a double pole MCB shall be provided in bus section panel.

5.17.2 Power supply for space heaters of motors shall be tapped from this bus by means of a MCB located in the motor feeder compartment. These MCBs shall be of triple pole and rated for 15 Amp.

6.0 COMPONENT DETAILS

Components of the switchgear shall ensure type of coordination ‘C’ as per IS:60947 (Part 4/ Section 1). Makes of all components shall be subject to owner’s / consultant’s approval

6.1 Circuit Breaker
6.1.1 The circuit breakers shall comply with the requirement of IS/IEC 60947.

6.1.2 All circuit breakers shall be of P2 (0-3 min - CO - 3 min - CO) category, capable of carrying the specified current at the site conditions and making/breaking of the system fault current.

6.1.3 Type test certificates from an independent testing authority shall be furnished along with the offer for each circuit breaker rating and type.

6.1.4 The circuit breakers controlling motors shall be suitable for DOL starting and stopping of induction motor a number of times.

6.1.5 The circuit breakers controlling capacitors shall be suitable for energizing and de-energizing the rated capacitor bank.

6.1.6 The circuit breakers shall be of the 3 phase, 4 pole horizontal draw out, horizontal isolation, air break type.

6.1.7 The circuit breaker shall be suitable for electrical or manual closing as specified. Manual operated breakers shall have independent manual spring closing mechanism. In case of electrically operated breaker, it shall have motor wound spring mechanism. In all cases tripping shall be by means of shunt trip coil.

6.1.8 All circuit breaker units of the same rating shall be physically and electrically interchangeable.

6.1.9 The circuit breakers shall be electrically and mechanically trip free and provided with anti-pumping feature.

6.1.10 Provision shall be made for slow closing for maintenance purposes. A suitable handle shall be provided one for each board for this purpose.

6.1.11 The circuit breakers shall have three positions i.e. service, test and isolated with the cubicle door closed. Necessary stoppers shall be provided to prevent the excessive movement of the breaker cradle than desired for the position. Service and test positions of the breaker shall have monitoring switch having 1NO+1NC contacts.

6.1.12 The circuit breaker shall be provided with emergency manual trip device, mechanical ‘ON’, ‘OFF’ and ‘ISOLATED’ position indicators and operation counter.

6.1.13 A maintenance truck/device for raising, lowering and withdrawal of the circuit breaker shall be supplied for each switch board.

6.1.14 The arc interrupting devices shall be capable of interrupting satisfactorily current from zero to the rated interrupting current when used on predominantly capacitive or inductive circuits, without requiring excessive maintenance of the contacts. The arc shall be restricted within the interrupting chamber and no emission of flame shall be allowed which may cause electrical breakdown or damage to insulation on the apparatus.

6.1.15 The main contacts shall be self aligning, adjustable and replaceable type.

6.1.16 The arcing contacts shall be easily accessible for maintenance and inspection and shall be easily replaceable type. They shall be provided with, contact face of special arc-resisting and non-pitting metal.

6.1.17 Mechanical safety interlock shall be provided for safe operation and movement of the breaker.

6.1.18 The circuit breakers shall be provided with minimum of four normally open and four normally closed auxiliary switch contacts, over and above those required for its own control scheme, for Owner’s use. The contacts shall be wired separately to the terminal board.

6.2 **Moulded Case Circuit Breakers**
6.2.1 The circuit breaker shall conform to IS/IEC 60947 and shall be of P2 category having
rupturing capacity as per system requirement and mounted on a draw out chassis.
6.2.2 The circuit breaker shall be provided with spring assisted quick make quick break type
manually operated trip free mechanism, mechanical ‘ON’, ‘OFF’ position indicators,
thermal tripping devices of inverse characteristics, instantaneous short circuit tripping
devices and necessary auxiliary and alarm switches. The MCCB Chassis shall be
provided with service, test and isolated position and automatic safety shutter.
6.2.3 The thermal and short circuit tripping devices shall be adjustable type.
6.2.4 When used for motor circuits, shunt trip device shall be provided and the let through
power of controlling MCCB shall be lower than the respective contactor.
6.2.5 In addition, under voltage trip shall be provided.

6.3 Switches

6.3.1 The switches shall be motor duty type AC 23 Category and shall comply with the
requirements laid down in IS/IEC 60947. Switches up to 63 Amps shall be rotary type
and those of 100 Amps & above, link type.
6.3.2 ‘ON’ and ‘OFF’ position of the switches shall be indicated on the module. Provision shall
be made to lock the switch in the ‘OFF’ position.
6.3.3 The fixed contacts shall be shrouded type. All contacts shall be silver plated.

6.4 Fuses

6.4.1 The fuses shall be of non-deteriorating HRC cartridge link type and shall conform to IS:
13703. They shall be suitable for the load and service required in the circuit.
6.4.2 One fuse puller shall be supplied along with each board.

6.5 Air Break Contactors

6.5.1 The Air Break Contactors shall be of Category AC3/AC4, unless otherwise specified,
conforming to IS: 60947 and flapper type.
6.5.2 The dropout voltage shall not exceed 65% of rated voltage.
6.5.3 Each contactor shall be provided with auxiliary contacts as required. The rating of the
auxiliary contacts shall be 5 Amps. AC or 1 Amp DC at the specified control voltages.
The spare auxiliary contacts shall also be wired up to the terminal blocks.

6.6 Bimetal Thermal Overload Relays

6.6.1 The contactor shall be provided with three pole bimetal thermal overload relays, unless
other-wise specified. The bimetal relays shall be of suitable range, ambient temperature
compensated and shall be separate mounting type. They shall be adjustable through
graduated scale and shall be provided with changeover contact. Thermal relays having
long time/current characteristics, operated through saturated C.T.s shall be supplied,
wherever required.
6.6.2 Bimetal thermal relays shall conform to IS: 3231 and IS/IEC 60947 and shall have built-
in single phasing preventor.
6.6.3 The bimetal relays shall be provided with a manual resetting device resetable after
opening module door. Auto reset thermal relays are not acceptable.

6.7 Current Transformers
6.7.1 The current transformers shall conform to IS: 2705.

6.7.2 C.T.s shall be Class F insulated and vacuum impregnated or resin cast. The C.T.s shall be rigidly mounted and shall be easily accessible for maintenance and testing.

6.7.3 The short time thermal withstand ratings of C.T.s shall be same as the thermal withstand rating of the breakers.

6.7.4 The C.T.s output shall be minimum 15VA for breaker feeders and 7.5 VA for the other feeders per phase and in any case, the output shall be adequate for the protection and metering duties involved with sufficient margin. The C.T.s shall have the following accuracies for the various applications:

<table>
<thead>
<tr>
<th>Application</th>
<th>Class of accuracy as per IS: 2705</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) For metering service</td>
<td>- 1</td>
</tr>
<tr>
<td>ii) For use with protective relays</td>
<td>- 5P</td>
</tr>
<tr>
<td>iii) For use with restricted earth fault</td>
<td>- PS</td>
</tr>
</tbody>
</table>

6.7.5 The C.T. cores for metering and protection shall be separate.

6.7.6 The ratio of C.T.s shall be as specified in Feeder details.

6.7.7 All the C.T.s shall be provided with terminals and shorting links. One of the terminals of the C.T. shall be earthed. The polarity of the C.T.s shall be clearly marked.

6.7.8 Provision of Interposing C.T.s is not acceptable.

6.7.9 The C.T.s shall be capable of withstanding momentary open circuit on the secondary side without injurious effects.

6.8 Voltage Transformers

6.8.1 The V.T.s shall be Class F insulated and vacuum impregnated or resin cast conforming to IS: 3156.

6.8.2 The primary nominal voltage shall be equal to the system nominal voltage. The secondary terminal voltage shall be 110 V.

6.8.3 The primary and secondary winding shall be protected by HRC fuses in each phase except in the ground phase of the secondary side.

6.8.4 The V.T.s shall be mounted on separate withdrawable carriage. The accuracy Class of V.T.s shall be 1.

6.8.5 The rated output of each V.T. shall be adequate for the relays, meters and associated wiring connected to it and shall not be less than 50 VA per phase.

6.9 Control Transformers

These shall be air cooled Class F insulated and vacuum impregnated. The rating of control transformer shall be twice the hold on VA of all contactor/relays or 2.5 KVA whichever is high. It shall be free from hum and rigidly mounted. Epoxy cast transformers shall be preferred.

6.10 Transformers for Kondorffer Starting

These shall be three phase core type, Class F insulated and vacuum impregnated. Tapping at 90%, 80%, 70% & 60% shall be provided and terminals shall be brought out
for easy change of tapping at site. The operating temperature shall not exceed 80°C. The transformers shall be suitable for taking 7.5 times the specified full load current of the motor continuously for 120 secs.

6.11 Relays

6.11.1 All protective relays shall be of latest version, microprocessor based numerical type with communication port and interlinked with online energy management system. 100% redundancy shall be provided for communication.

6.12 Timers

The timers shall be electronic pneumatic or synchronous type with manual/auto reset features as per the functional requirements. The time delay shall be 'ON' delay or 'OFF' delay type as specified. The repeat accuracy shall be 0.5% or better.

6.13 Single Phasing Preventor

6.13.1 Single phasing preventor relay shall be of the current operated type, suitable for the system voltage. The relay shall not operate for normal system voltage but operate positively in the event of unbalanced voltage more than the normal. The relay shall not operate in case of total interruption of power.

6.13.2 The relay shall be fail safe, self reset type and provided with flag indication. The relay operation shall be independent of the motor rating, loading and speed.

6.14 Instruments and Meters

6.14.1 All instruments shall be flush mounting type with square face of 96 mm x 96 mm. They shall be tropicalized and dust tight.

6.14.2 Meters shall be digital multifunctional meters with communication port for energy management at remote location.

6.14.3 All ammeters and voltmeters, to be provided separately, shall have 0-90º scale and shall be moving iron spring controlled type of class 1.5 accuracy as per IS: 1248. The scale range of the ammeters and voltmeters shall be as indicated in the Feeder details.

6.14.4 In case of motor feeders, the ammeters shall be graduated uniformly upto C.T. primary current and with compressed end scale upto 6 times C.T. primary current. Red pointer shall be provided, which shall be adjusted at site for indicating full load current of the motor.

6.15 Push Buttons and Control Switches

6.15.1 The switches and push buttons shall conform to utilization category AC11/DC11 as per IS: 60947. The contact shall be rated to make, break and carry inductive current of 5 Amp at 415 V AC and 1 Amp at 220 V DC.

6.15.2 The control switches shall be spring return rotary type, unless otherwise specified and provided with pistol grip type handle. The control switches for circuit breakers shall be additionally fitted with lost motion devices and sequencing devices.

6.15.3 The selector switches shall be stay put rotary type and provided with oval shape handles.

6.15.4 The push buttons shall be of momentary contact spring loaded type with a set of normally close and open contacts. The push button for ‘Start’ shall be shrouded type and coloured green, stop push button shall be un-shrouded type and coloured red and other push buttons shall be un-shrouded type coloured black. The fixing ring shall be metallic white.
6.15.5 Emergency stop push buttons, if specified, shall be lockable in pushed position.

6.16 **Miniature Circuit Breakers**

6.16.1 The miniature circuit breakers shall conform to IS: 8828 and shall be of duty category M-9.

6.16.2 It shall be provided with overload and short circuit protective devices in a heat resistant housing.

6.16.3 A certificate for short circuit rating and Current-Time tripping curve shall be furnished along with the offer.

6.17 **Signal Lamps**

6.17.1 Signal lamps shall be provided to indicate the various circuit conditions as shown in scheme drawings. The colour of the lamps for various functions shall be as follows:

- Red -- Circuit breaker/switch/contactor closed.
- Green -- Circuit breaker/switch/contactor open.
- White -- Trip circuit healthy.
- Amber -- Alarm and auto trip.
- Blue -- Non-Trip

6.17.2 All lamps shall be of LED type with lumen output of 200 mili candela in axial direction.

7.0 **ACCESSORIES**

7.1 The supply shall include the following accessories:

- Maintenance truck/device for raising, lowering and withdrawal of circuit breaker, if required.
- Fuse puller.
- Test plug for relays.
- Test plug for kWh meters.

7.2 **Space Heater**

Each vertical section shall be provided with a thermostatically controlled space heater, rated for 240 V, 50 Hz and controlled through double pole miniature circuit breaker.

7.3 **Name Plates**

7.3.1 The switchboard shall have large name plate on the top indicating its Name, Designation and Code No.

7.3.2 Each feeder shall be provided with name plate. Each single front panel shall have name plate indicating panel number both in front and back.

7.3.3 All control switches, push buttons, lamps etc. shall have functional identification labels.

7.3.4 Name plate shall be of black Perspex with white engraving and of minimum 3mm thick.

7.4 Any other accessories required, but not specified, shall also be supplied to make the switchboard complete in all respects and ensure safe and proper operation.

8.0 **PAINTING**
8.1 The enclosure, after degreasing, pickling in acid, cold rinsing, phosphatising, passingivating etc. shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 Unless otherwise specified, the finishing shade shall be light grey having Shade No.631 as per IS: 5.

8.5 One litre of paint shall be supplied along with each board for touch up at site.

9.0 TESTS AND INSPECTION

9.1 All the switchboards shall be subjected to routine test as per IS: 8623 and their components as per relevant standards.

9.2 Additional tests, wherever specified, shall be carried out.

9.3 All the above tests shall be carried out in presence of Purchaser’s representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.

9.4 These inspections shall however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following description written boldly:

-- Name of Client
-- Name of Consultant
-- Enquiry / Order Number with Project / Plant Name
-- Code No. & Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of spare parts shall be quoted.

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the switch boards.

12.0 PACKING
12.1 The board shall be properly packed before despatch to avoid damage during transport, storage and handling.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
## ANNEXURE - I

### DOCUMENTATION FOR MEDIUM VOLTAGE SWITCHBOARDS

<table>
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<th>Sl.No.</th>
<th>Documentation Description</th>
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<tr>
<td>1.</td>
<td>Specification Sheets</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<td>2.</td>
<td>Technical Particulars</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>3.</td>
<td>Feeder Details</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>4.</td>
<td>General arrangement and Foundation Drgs.</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>5.</td>
<td>Schematic and Wiring Diagrams</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<td>6.</td>
<td>Calculation for Bus-bar sizing</td>
<td>N</td>
<td>Y</td>
<td>N</td>
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<td>7.</td>
<td>Terminal Arrangement Drgs.</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>8.</td>
<td>Illustrative and Descriptive Literature</td>
<td>N</td>
<td>N</td>
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<tr>
<td>9.</td>
<td>Catalogues for bought out accessories.</td>
<td>N</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>10.</td>
<td>Installation, Operation and maintenance manual.</td>
<td>N</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>11.</td>
<td>Test Certificates</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>i) Type -- Switchboard</td>
<td>N</td>
<td>N</td>
<td>N</td>
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<tr>
<td></td>
<td>-- Circuit Breaker</td>
<td>N</td>
<td>N</td>
<td>N</td>
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<td></td>
<td>-- MCCB's</td>
<td>N</td>
<td>N</td>
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<td>ii) Routine</td>
<td>N</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>12.</td>
<td>Guarantee Certificates</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>13.</td>
<td>Spare Parts List</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>

### Note:

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N – No
TECHNICAL SPECIFICATION

HIGH VOLTAGE SWITCHBOARDS
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ANNEXURE - I DOCUMENTATION FOR HIGH VOLTAGE SWITCHBOARDS
1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of High Voltage Switch Boards.

1.2 This standard shall be read in conjunction with relevant part of Design Philosophy – Electrical, Schematic diagrams etc.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment shall comply with the latest issues of the following standard, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

IS: 3427 A.C. Metal enclosed switchgear and control gear for rated voltages above 1 kV up to and including 52 kV.

IS: 13118 Specification for high voltage alternating current circuit breakers.


IS: 11353 Guide for uniform system of marking and identification of conductors and apparatus terminals.

IS: 10118 Code of Practice for selection, installation and maintenance of switchgear and control gear.

Various components housed in the switchboards shall conform to the Indian Standards Specification as mentioned against the component details or IEC Specifications.

2.2 The design and operational features of all the equipment offered shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications / IEC Specification, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy – Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy – Electrical.

4.0 OPERATING REQUIREMENTS

The switchboards shall be suitable for operating at the specified rating continuously, with the specified voltage and frequency variations under the ambient conditions, without exceeding the permissible temperature rise and without any detrimental effect on any part.

5.0 DESIGN AND CONSTRUCTIONAL FEATURES

5.1 General

5.1.1 The switchboards shall consist of an assembly of a series of floor mounting, identical,
metal clad, cubicle type panels placed side by side to form a compact assembly and shall be extensible on either side.

5.1.2 The complete assembly shall be dust, damp and vermin proof having minimum degree of protection equivalent to IP4X as per IS/IEC:60529. However, in case some ventilation openings are to be provided, these may be permitted for equipment located indoors and such openings shall be covered by fine wire mesh ensuring minimum IP3X protection.

5.1.3 The framework of the cubicles shall be bolted / welded construction. The minimum thickness of sheet steel shall be 3 mm for base channel and 2 mm for other members. The doors and covers shall be fabricated from cold rolled sheet steel. Suitable reinforcement, wherever necessary, shall be provided.

5.1.4 The switchboard shall be mounted on the channel which shall be included in the vendor's scope.

5.1.5 Each cubicle shall be provided with front access door with handle lock and key for breaker compartment and a removable back cover. The door hinges shall be concealed type. Front doors of the panels shall mechanically stop in full open position to facilitate removal of breakers and for ease of maintenance.

5.1.6 All external hardwares shall be cadmium plated. The hardwares for fixing removable parts shall be provided with retaining devices.

5.1.7 The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets. Gaskets without any discontinuity shall be preferred. Gaskets shall be held in position in groove, in shaped sheet steel work or these shall be U-type.

5.1.8 Each cubicle shall have separate compartment within the cubicle for circuit breaker, bus-bars, instrument transformers, metering and relaying devices and cable termination.

5.1.9 Inter-panel and inter-compartment fire resistant barrier shall be provided. Cast resin seal off bushing shall be provided in the bus compartment, through which connections to breaker compartment/cable compartment/bus compartment of adjacent panel shall be taken. Failure of one of the equipment shall not effect the equipment in the adjacent compartment.

5.1.10 All the components shall be accessible for inspection and maintenance without the necessity of removing the adjacent ones. Their mounting shall be accessible and ensure the necessary degree of safety.

5.1.11 The layout of the components inside the cubicle shall be liberal to facilitate maintenance and the interconnecting wiring between components shall not be subjected to undue stresses at the bends.

5.1.12 Mounting height of components requiring operation and maintenance shall not be lower than 300 mm and higher than 1800 mm.

5.1.13 All live parts which are accessible after opening of front and back door/cover shall be properly insulated or provided with insulating barrier to prevent accidental contact. Phase insulating barriers shall be provided between the breaker poles. Removal facility shall be provided for all such barriers.

5.1.14 Adequate arrangement for earthing shall be provided to safeguard the operator or other personnel from electric hazards under all conditions of operation.

5.1.15 The switchboard shall be provided with following interlocks and safety features:

i) The withdrawal and engagement of a circuit breaker shall not be possible unless it is in open position.

ii) The operation of a circuit breaker shall not be possible unless it is in fully service, test or isolated position.

iii) It shall not be possible to close the circuit breaker in service position unless all
auxiliary and control circuits are connected.

iv) A breaker of the lower rating shall be prevented from engaging with the stationary element of higher rating.

v) Insertion of the manual mechanism shall render the motorized mechanism inoperable.

vi) Circuit breaker “ON”, “OFF” indication shall be provided at the back of each panel.

vii) Caution name plate shall be provided at the back of incomer panels where terminals are likely to remain live and isolation is possible only from remote end.

viii) Automatic safety shutter, with padlocking facility for locking in closed position, to completely cover the spouts for bus-bars and cable connection when the breaker is withdrawn.

5.2 Bus-Bars and Connections

5.2.1 The bus-bars shall be for three phases. The bus-bars and connection shall be made of electrolytic grade copper of rectangular cross-section.

5.2.2 Bus-bars and connections shall be sleeved to protect against approach to live parts and to eliminate potential arcing points. Sleeving material shall have adequate electrical, thermal and mechanical properties to withstand impulse level, temperature rise during normal and short circuit condition and allow easy bending of bus bars.

5.2.3 The bus-bars shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding the limits specified in IS: 8084. The thermal rating of the bus-bars shall be designed to withstand the system fault current for 3 seconds without exceeding the limiting temperature of 250°C for bare copper. Calculation for bus-bar sizing shall be furnished along with the offer.

5.2.4 Horizontal bus-bars shall run in a separate compartment through the entire length of the board and shall be of same cross-section throughout. Stepped bus-bars shall not be acceptable.

5.2.5 The bus-bars shall be arranged and colour coded according to IS: 5578 & IS: 11353.

5.2.6 The bus-bars chamber shall be sufficiently spacious and shall have separate screwed covers for maintenance purpose. It shall be adequately ventilated and shall allow the escape of the hot gases.

5.2.7 The bus-bars shall be rigidly supported at equal intervals to withstand the stresses due to full short circuit and also to take care of thermal expansion.

5.2.8 A minimum of two bolts shall be used per bus-bar joint. Only high tensile electro galvanized cadmium plated bolts, nuts and washers shall be used. The washers shall be spring and plain type. The bus-bar supports shall be of molded construction with built-in anti-tracking barriers. The support materials shall be of DMC or fiber glass reinforced thermosetting plastic.

5.2.9 The bus-bars, both horizontal and vertical, shall be PVC sleeved. Insulating shrouds shall be provided for all joints of insulated bus-bars.

5.3 Earth Bus

A continuous earth bus of Aluminium running along the lower part of the switchboard shall be provided with two end terminals with lugs for external connection. The earth bus shall be rated to carry three phase fault current for a period of 3 sec.

5.4 Bus Duct

5.4.1 Suitable extension of bus-bars in proper phase sequence on the top, with connecting
bolts shall be provided where connections between transformer and switchboard or between two halves of the switchboard is specified to be through bus duct.

5.4.2 Bus duct between two halves of the switchboard, if required, shall be supplied by the switchboard manufacturer. The bus-bars of interconnecting bus duct shall be similar to the main bus-bars of switchboard as specified above and shall conform to IS: 8084.

5.4.3 Bus duct between transformer and switchboard, if included in vendor’s scope shall conform to IS: 8084.

5.5 **Clearances and Creepage Distance**
The clearance and creepage distance shall be adequate to meet the BIL of the equipment.

5.6 **Insulation**

5.6.1 The insulation used shall be non-hygroscopic and shall be of porcelain, epoxy resins or fiber glass molded with plastic. It shall be of adequate electrical, mechanical and thermal strength to give trouble free service during normal operation and short circuit conditions.

5.6.2 The insulation shall be treated suitably to withstand the tropical conditions and atmospheric pollution.

5.7 **Control Wiring**

5.7.1 The switchboard shall be completely factory wired and ready for external connections.

5.7.2 The wiring shall be complete in all respect so as to ensure proper functioning of control, interlocking, protection, metering, indications and annunciations.

5.7.3 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables of 1100 Volt grade. The minimum size of wires shall be as follows:

- C.T. Circuit: 2.5 Sq. mm
- V.T. and Control Circuits: 1.5 Sq. mm

5.7.4 All wiring shall be provided with dependent both ends marking as per IS: 5578. Numbered ferrules, reading from the terminal outwards, shall be provided at both ends of all wiring for easy identification. These shall be interlocking type plastic ferrules.

5.7.5 Control wiring circuits, fed from a supply common to a number of panels, shall be so protected that failure of a circuit in one panel does not affect the operation of other panels.

5.7.6 The wiring to the equipment mounted on the doors shall be carried out with flexible multi-strand copper conductor cable and so supported that on opening of the door, there is no undue strain on wire leads.

5.7.7 The control cables shall be neatly arranged and properly supported.

5.8 **External Cable Termination**

5.8.1 All power and control cables shall enter the switchboard from the bottom on the back of the panel. Sufficient space shall be provided for ease of connection and termination of cables.

5.8.2 All power cables and control cables shall be of type, number and size as indicated in Feeder Details.

5.8.3 The termination arrangement for single core cables shall be such that so as to minimize flow of eddy current and heating due to eddy currents.

5.8.4 Heavy duty double compression type rolled Aluminium cable glands along with the cable lugs, as required shall be provided for termination of control cables and auxiliary
power supply cables.

5.8.5 The cable glands shall be mounted on a removable gland plate, provided at a minimum height of 75 mm from the bottom of the switchboard. Two number spare knockouts of size 20 mm shall also be provided on the gland plate for future use.

5.8.6 Terminal blocks shall be provided at suitable locations inside the panels for termination of control and auxiliary power supply wiring. These terminal blocks shall be pressure clamp type up to 35 sq. mm cables and bolted lug type for higher sizes of cables. These shall be protected type and rated for 1100 Volt service. The minimum current rating of the terminal block shall be 16 Amp.

5.8.7 Where more than two cables in parallel are required to be terminated, a system of bus links shall be provided with adequate clearance and spacing.

5.8.8 The terminal block shall be grouped according to circuit functions and numbered suitably. 20% extra terminals shall be provided in the terminal block.

5.8.9 Suitable clamps to support the vertical run of cables shall be provided.

5.8.10 For power connections, suitable marking on the terminals shall be provided to identify the phases.

5.9 **Feeder Details**

5.9.1 The requirements of incomer, bus coupler and outgoing feeders shall be as indicated in the single line diagram, feeder details and corresponding schematic diagrams.

5.9.2 Non-paralleling interlocks shall be provided between incomers and bus section panels. The interlocks shall be either electrical or mechanical type. Arrangement for defeating the interlock shall also be provided.

5.9.3 Auto changeover scheme, wherever specified, shall be provided.

5.10 **Dummy Panels**

Dummy panels complete with bus-bar system in 400 mm width shall be required for which unit price shall be indicated.

5.11 **Control Power Supply**

5.11.1 D.C. power required for closing, tripping and indication shall be supplied at the bus coupler panel through two completely separate circuits by the owner, one for tripping and another for closing and indication for the whole board.

5.11.2 For receiving each external control power supply, a double pole miniature circuit breaker shall be provided. This power shall be distributed inside the switchboard for each feeder having its MCB unit.

5.12 **Space Heater Power Supply**

5.12.1 Panel space heaters shall be fed from a separate bus, common for the whole board. This bus shall be fed from owner's supply for which a double pole MCB shall be provided in bus section panel.

5.12.2 Power supply for space heaters of motors shall be tapped from this bus by means of miniature circuit breakers located in the motor feeder panels. These MCB’s shall be of triple pole and rated for 15 Amp.

6.0 **COMPONENT DETAILS**

6.1 **Circuit Breakers**

6.1.1 The circuit breakers shall comply with the requirements of IS: 13118.
6.1.2 All circuit breakers shall be of 0-3 min-CO-3 min-CO rated operating sequence capable of carrying the specified current at the site conditions and making/breaking of the system fault current.

6.1.3 Type test certificates from an independent testing authority shall be furnished along with the offer for each circuit breaker rating and type.

6.1.4 The circuit breakers controlling motors shall be suitable for DOL starting and stopping induction motor a number of times and shall have provision to limit over voltage to the value safe for motor insulation. Unless otherwise specified this value shall be taken as 2.5 times the rated voltage. The magnitude of the voltage surge produced by the breaker when switching off the smallest motor shall be indicated.

6.1.5 The circuit breakers controlling capacitors shall be suitable for energizing and de-energizing the rated capacitor bank.

6.1.6 The circuit breakers shall be of the 3 phase, single/double break, horizontal draw-out, vertical/horizontal isolation type. The medium of arc quenching shall be minimum Oil/Bulk oil/vacuum/SF6 as specified elsewhere.

6.1.7 The circuit breakers shall be suitable for electrical/manual closing as specified in Feeder details. Electrically operated circuit breakers shall preferably have motor wound spring closing mechanism with provision for manual closing arrangement. Manually operated circuit breakers shall have independent manual spring closing mechanism. In all cases tripping shall be by means of shunt trip coil.

6.1.8 All circuit breaker units of the same rating shall be physically and electrically interchangeable.

6.1.9 The circuit breakers shall be electrically and mechanically trip free and provided with anti-pumping feature.

6.1.10 The circuit breakers shall have three positions, i.e. service, test and isolated with the cubicle door closed. Necessary stoppers shall be provided to prevent the excessive movement of the breaker cradle than desired for the position. Service and test positions of the breaker shall have monitoring switch having 1NO+1NC contacts.

6.1.11 The circuit breakers shall be provided with emergency manual trip device, mechanical ‘ON’, ‘OFF’, ‘ISOLATED’ position and spring ‘CHARGED’, ‘DISCHARGED’ indicators and operation counter.

6.1.12 A maintenance truck/device, if required, for raising, lowering and withdrawals of the circuit breaker shall be supplied for each switchboard.

6.1.13 The arc interrupting devices shall be capable of interrupting satisfactorily current from zero to the rated interrupting current when used on predominantly capacitive or inductive circuits, without requiring excessive maintenance of the contacts. The arc shall be restricted within the interrupting chamber and no emission of flame shall be allowed which may cause electrical breakdown or damage to insulation on the apparatus.

6.1.14 Mechanical safety interlock shall be provided for safe operating and movement of the breaker.

6.1.15 The circuit breakers shall be provided with minimum of four normally open and four normally closed auxiliary switch contacts, over and above those required for its own control scheme, for owner’s use. These contacts shall be wired separately to the terminal board.

6.1.16 The closing coil and other associated auxiliary relays shall operate satisfactorily at all voltages between 85% and 110% of the rated control voltage. The tripping coil and other associated relays shall operate satisfactorily at all voltages between 70% and 110% of the rated control voltage.
6.1.17 Cable earthing facility shall be provided in the circuit breaker for discharging of power cable through the circuit breaker contact with circuit breaker in drawn-out position. An integral earthing arrangement shall be preferred. In case the integral earthing arrangement is not feasible due to circuit breaker design, a separate earthing truck, which shall be inserted in place of circuit breaker, shall be provided per board.

6.1.18 Positive earthing of circuit breaker frame shall be maintained at every position of circuit breaker. The earthing contact shall be line/scraping type and not of point type.

6.2 Current Transformers

6.2.1 The current transformers shall conform to IS: 2705.

6.2.2 C.T.s shall be class F insulated and vacuum impregnated or resin cast type. The C.T.s shall be rigidly mounted and shall be easily accessible for maintenance and testing.

6.2.3 The short time thermal withstand ratings of the C.T.s shall be same as the thermal withstand ratings of the breakers.

6.2.4 The C.T.s output shall be minimum 15 VA per phase and in any case, the output shall be adequate for the protection and metering duties involved with sufficient margin. The C.T.s shall have the following accuracies for the various applications:

<table>
<thead>
<tr>
<th>Application</th>
<th>Class of Accuracy as per IS: 2705</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) For metering service</td>
<td>1</td>
</tr>
<tr>
<td>ii) For use with protective relays</td>
<td>5 P</td>
</tr>
<tr>
<td>iii) For use with restricted earth fault and differential relays</td>
<td>PS</td>
</tr>
</tbody>
</table>

6.2.5 The C.T. cores for metering and protection shall be separate.

6.2.6 The ratios of the current transformers shall be as indicated in Feeder details.

6.2.7 All the C.T.s shall be provided with terminals and shorting links. One of the terminals of the C.T. shall be earthed. The polarity of the C.T. shall be clearly marked.

6.2.8 Provision of interposing C.T. is not acceptable.

6.2.9 The C.T.s shall be capable of withstanding momentary open-circuit on the secondary side without injurious effects.

6.3 Voltage Transformers

6.3.1 The V.T.s shall be class F insulated and vacuum impregnated or resin cast type conforming to IS: 3156.

6.3.2 The primary nominal voltage shall be equal to the system nominal voltage. The secondary terminal voltage shall be $110 / \sqrt{3}$ V.

6.3.3 The rated output of each VT shall be adequate for the relays, meters and associated wiring connected to it with sufficient margin and shall not be less than 200 VA per phase.

6.3.4 The accuracy class of V.T.s shall be 1 as per IS: 3156.

6.3.5 The primary and secondary winding shall be protected by HRC fuses in each phase except in the grounded phase of the secondary side.

6.3.6 The V.T. shall be mounted on a with-drawable carriage. Shutters with padlocking facility, provided on high voltage sides, shall be so arranged that the live orifices are automatically closed when the V.T. is withdrawn.

6.3.7 Mechanical interlocking arrangement shall be provided so that the access to the high voltage fuse is possible only when the V.T. is fully withdrawn.
6.4 Relays
6.4.1 All protective relays shall be of latest version, microprocessor based numerical type with communication port and interlinked with online energy management system. 100% redundancy shall be provided for communication.

6.5 Timers
6.5.1 The timers shall be electronic, pneumatic or synchronous type with manual/auto reset features as per the functional requirements. The timers shall be ‘ON’ delay or ‘OFF’ delay type as specified. The repeat accuracy shall be 0.5% or better.

6.6 Instruments and Meters
6.6.1 All instruments shall be flush mounting type with square face of 96 mm x 96 mm. They shall be tropicalized and dust tight.
6.6.2 Meters shall be digital multifunctional meters with communication port for energy management at remote location.
6.6.3 All ammeters and voltmeters, to be provided separately, shall have 0-90° scale and shall be moving iron spring controlled type of class 1.5 accuracy as per IS: 1248. The scale range of the ammeters and voltmeters shall be as indicated in the Feeder details.
6.6.4 In case of motor feeders, the ammeters shall be graduated uniformly upto C.T. primary current and with compressed end scale upto 6 times C.T. primary current. Red pointer shall be provided, which shall be adjusted at site for indicating full load current of the motor.

6.7 Push Buttons and Control Switches
6.7.1 The switches and push buttons shall conform to utilization category AC11/DC11 as per IS/IEC:60947. The contact shall be rated to make, break and carry inductive current of 5 Amps. at 415 V AC and 1 Amp. at 220 V DC.
6.7.2 The control switches shall be spring return rotary type, unless otherwise specified and provided with Pistol grip type handle. The control switches for circuit breakers shall be additionally fitted with lost motion devices and sequencing devices, if required.
6.7.3 The selector switches shall be stay put rotary type and provided with oval shape handles.
6.7.4 The push buttons shall be of momentary contact spring loaded type with a set of normally close and open contacts. The start push button shall be shrouded type and coloured green. The stop push button shall be un-shrouded type and coloured red and other push buttons shall be un-shrouded type and coloured black. The fixing ring shall be metallic white.
6.7.5 Emergency stop push buttons, if specified, shall be lockable in pushed position.

6.8 Control Fuses
6.8.1 The fuses shall be non-deteriorating HRC cartridge link type and shall conform to IS: 13703. They shall be suitable for load and service required in the circuit.
6.8.2 One fuse puller shall be supplied along with each board.

6.9 Miniature Circuit Breakers
6.9.1 The miniature circuit breakers shall conform to IS: 8828 and shall be of duty category M-9.
6.9.2 It shall be provided with overload and short circuit protective devices in a heat resistant housing.
6.9.3 Type test certificate for short circuit rating and current time tripping curve shall be
furnished along with the offer.

6.10 **Signal Lamps**

6.10.1 Signal lamps shall be provided to indicate the various circuit conditions as shown in scheme drawings. The colour of the lamps for various functions shall be as follow:

- **Red** - Circuit breaker ‘ON’
- **Green** - Circuit breaker ‘OFF’
- **White** - Trip circuit healthy
- **Amber** - Alarm and auto trip
- **Blue** - Non-Trip

6.10.2 The lamps shall LED type with lumen output of 200 millicandella in axial direction.

7.0 **ACCESSORIES**

7.1 The supply shall include the following accessories.

- Maintenance truck/device for raising, lowering and withdrawal of circuit breaker, if required.
- Earthing truck, in case the integral earthing arrangement is not feasible in the circuit breaker.
- Fuse puller.
- Test plug for relays.
- Test plug for kWh meters.
- Special tools and tackles, as required.

7.2 **Space Heater**

7.2.1 Each panel shall be provided with a thermostatically controlled space heater, rated for 240 V, 50 Hz and controlled through double pole miniature circuit breaker.

7.3 **Name Plates**

7.3.1 The switchboard shall have large name plate on the top to indicate its name and designation.

7.3.2 Each panel shall be provided with name plate both in front and back.

7.3.3 All control switches, push buttons, lamps etc. shall have functional identification labels.

7.3.4 Name plate shall be of black Perspex with white engraving and of minimum 3 mm thick.

7.4 Any other accessories required, but not specified, shall also be supplied to make the switchboard complete in all respects and ensure safe and proper operation.

8.0 **PAINTING**

8.1 The enclosure, after degreasing, pickling in acid, cold rinsing, phosphatising, passivating etc. shall be painted with two coats of anti-rust paint followed by two coats of anti-corrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 Unless otherwise specified, the finishing shade shall be light grey having shade No.631 as per IS: 5.

8.5 One litre of paint shall be supplied along with each board for touch up at site.
9.0 TESTS AND INSPECTION

9.1 All the switchboards shall be subjected to routine test as per IS: 3427 and their components as per relevant standards.

9.2 Additional tests, wherever specified, shall be carried out.

9.3 All the above tests shall be carried out in presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.

9.4 These inspection shall, however, not absolve the vendor from his responsibility for making good any defect which shall be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following description written boldly.
   - Name of client
   - Name of consultant
   - Enquiry / Order Number with plant / project name
   - Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance
   Item wise unit prices of spare parts shall be quoted.

11.2 Commissioning Spares
   Commissioning Spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipments.

12.0 PACKING

12.1 The switchboard shall be properly packed before dispatch to avoid damage during transport, storage and handling.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
## ANNEXURE - I

### DOCUMENTATION FOR HIGH VOLTAGE SWITCHBOARDS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>With Bid</th>
<th>For Approval</th>
<th>Final</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Specification Sheets</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>2.</td>
<td>Technical Particulars</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>3.</td>
<td>Feeder Details</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>4.</td>
<td>General arrangement and Foundation Drawings</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>5.</td>
<td>Schematic/Wiring Diagrams</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>6.</td>
<td>Calculation for Bus-bar sizing</td>
<td>N</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>7.</td>
<td>Terminal Arrangement Drawings</td>
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<td>Y</td>
<td>Y</td>
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<tr>
<td>8.</td>
<td>Illustrative and Descriptive Literature</td>
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<td>N</td>
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<tr>
<td>9.</td>
<td>Catalogues for bought out accessories</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>10.</td>
<td>Installation, Operation and maintenance manual</td>
<td>N</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>11.</td>
<td>Test Certificates</td>
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<tr>
<td></td>
<td>i) Type - Switchboard</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>- Circuit Breaker</td>
<td>N</td>
<td>N</td>
<td>N</td>
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<td></td>
<td>- MCB</td>
<td>N</td>
<td>N</td>
<td>N</td>
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<td></td>
<td>ii) Routine</td>
<td>N</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>12.</td>
<td>Guarantee Certificates</td>
<td>N</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>13.</td>
<td>Spare Parts List</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N – No
TECHNICAL SPECIFICATION

BUS DUCT
<table>
<thead>
<tr>
<th>SECTION NUMBER</th>
<th>DESCRIPTION</th>
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<tr>
<td>ANNEXURE - I</td>
<td>DOCUMENTATION FOR BUS DUCT</td>
</tr>
</tbody>
</table>
1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture testing at works and despatch in well packed condition of bus duct.

1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of following Indian Standards unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

- IS: 8084 - Interconnecting bus-bars for A.C. Voltage above 1 KV up to and including 36 KV.
- IS: 8623 - Specification for low voltage switchgear and control gear assemblies.

2.2 The design and operational features of all the equipment offered shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other relevant Statutory Acts and Regulations. The supplier shall wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard differs from those in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient conditions

These shall be as indicated in Design Philosophy - Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy - Electrical.

4.0 OPERATING REQUIREMENTS

The bus duct shall be suitable for operating at the rated capacity continuously under the ambient conditions and with the voltage and frequency variations without exceeding the permissible temperature rise and without any detrimental effect on any part.

5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

5.1 Enclosures

5.1.1 The sheet steel enclosure for enclosing and supporting the bus-bars shall be made out of 14 SWG sheet steel, bolted on the angle iron framework.

5.1.2 The enclosure shall completely enclose the bus bars from all sides. It shall have degree of protection IP: 52 for indoor installation and IP: 55 with rain protection canopy for outdoor installation as per IS/IEC:60947. Where part of the bus duct is required for indoor installation and part for outdoor installation, the complete section shall be suitable for outdoor installation. Ventilation louvers, if necessary, shall be provided with fine wire mesh from inside, in that case the degree of protection shall be IP: 42. Neoprene gasket shall be provided on covers at joints.
5.1.3 Whether bus duct (with louvers) is installed outdoor or indoor, suitably rated space heater with thermostat control shall be provided at different locations inside the bus duct to avoid moisture condensation.

5.1.4 All external hardwares of diameter less than 8 mm shall be stainless steel and those of diameter 8 mm and above shall be mild steel cadmium plated or zinc passivated.

5.2 **Bus Bars and Connections**

5.2.1 The bus-bars in LV Bus duct shall be of three phase and neutral, non-segregated and air insulated type.

The bus-bars in HV Bus duct shall be of three phase, phase-segregated with insulating material.

5.2.2 The bus bars shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding the temperature limits specified in IS: 8084. The bus bars shall be designed to withstand the system fault current for one second without exceeding the total temperature of 200°C. Type test certificate of similar bus duct shall be furnished.

5.2.3 The bus-bars material shall be high conductivity Aluminium alloy conforming to grade E91E of IS: 5082/electrolytic grade copper.

5.2.4 The bus-bars shall be rectangular in shape and cross-sectional area of neutral bus-bars shall be half of phase bus-bars.

5.2.5 The sizes of bus-bars selected shall be subjected to approval by PDIL. The vendor shall furnish supporting calculations for bus-bars and enclosure sizes both under normal load and short circuit conditions as well as that of temperature rise along with the offer.

5.2.6 All the bus-bars shall be bare and without any painting. The bus-bars shall be arranged and provided with proper phase identification as per IS: 5578/11353.

5.3 **Joints and Bends**

5.3.1 Only lap joints shall be used for jointing the bus bars. The over lap shall be equal to the width of the bus bars.

5.3.2 The contact surfaces of the overlapping bus-bars shall be thoroughly cleaned followed by application of good quality electrical grease and bolted immediately. In case of Aluminium to copper joints, copper bus-bars in addition shall be preferably tinned.

5.3.3 The bolting schedule adopted shall ensure proper contact pressure. A minimum of two bolts shall be used per joint.

5.3.4 The contact pressure shall be 100-140 kg/cm². Only high tensile, zinc passivated or galvanized steel bolts shall be used along with large diameter flat washers of adequate thickness.

5.3.5 At the bends, the bus-bars shall bend at a radius of 2t where the ‘t’ is the thickness of the bus-bars and the radius is measured to the inside of bus-bars.

5.4 **Flexible Joints**

Flexible joints and connections shall consist of tinned laminated copper strips or Aluminium strips of required cross sectional area. Precautions as mentioned under 5.3.2 shall also be observed while marking joints with laminated copper plates. Filler plates of Aluminium as required shall be used.

5.5 **Expansion Joints**

Expansion joints, where necessary, to allow for longitudinal expansion and contraction of bus-bars and bus enclosures caused by temperature variation shall be provided.

5.6 **Bus Bar Supports**
5.6.1 The bus-bars shall be rigidly supported at equal intervals. The bus-bars supports shall be such that they withstand stresses to which they may be subjected under normal and short circuit conditions.

5.6.2 The supports shall be of moulded construction of fibre glass reinforced with thermosetting plastics or superior materials. The supports, where necessary, shall either have built-in anti-tracking barriers or painted with anti-tracking varnishes.

5.7 Clearances and Creepage Distance

5.7.1 The clearances and creepage distance shall not be lower than the values specified below for any part of the bus duct.

i) Minimum clearance between two live parts - 25 mm

ii) Minimum clearance between a live part and accidentally dangerous part - 25 mm

iii) Creepage distance - 30 mm

5.7.2 The clearances and creepage distance, as specified above, shall definitely be maintained throughout the bus bars system. Provision of bus-bar separators or barriers shall not be considered to reduce the clearances from the values specified above.

5.8 Terminal Chambers at Switchgear and Transformer End

5.8.1 The bus duct shall be suitable for bolting to the flanges provided at the transformer and switchgear end. The exact dimensions and details of these terminal chambers shall be made available at the time of execution.

5.8.2 Phase changeover arrangement wherever required shall be provided in one of the terminal chambers to connect the bus-bars between same phase terminals at switchgear and transformer ends.

6.0 ACCESSORIES

6.1 Earthing
Two continuous earth strips of Aluminium having minimum 300 sq. mm size shall be provided throughout the length of bus duct or shall be suitable for full short circuit fault current for 1 sec. whichever is more.

6.2 Drain Plug
Bus duct shall be provided with drain plug to remove condensed moisture when required.

6.3 Fire Barriers
Two sets of epoxy moulded fire barriers shall be provided on switchgear end as well as transformer end.

6.4 Name Plates
6.4.1 Each bus duct shall be provided with a name plate of stainless steel with letter embossed on them and located at convenient location.

6.4.2 The name plate shall contain all details as per IS: 8084.

6.5 Hardware
Required number of hardwares like bolts, nuts, plain washers, spring washers etc. shall be provided for jointing the bus duct with transformer as well as switchgears.

7.0 LAYOUT

7.1 The proposed bus duct routing between transformer and associated switchgear shall be as shown in the drawing enclosed with NIT. Where no layout drawing is enclosed, the schedule of quantities shall be followed for bidding. However, the exact routing and
details of switchgear and transformer end chambers shall be supplied at the time of order or drawing approval.

7.2 The successful vendor shall prepare final layout drawing for each bus duct with bill of materials and submit the same for PDIL/Purchaser’s approval.

8.0 PAINTING

8.1 The enclosure after degreasing, pickling in acid, rinsing, phosphatising, passivating etc. shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 Unless otherwise specified, the finishing shade shall be light grey having shade no. 631 as per IS: 5.

9.0 TESTS AND INSPECTION

9.1 The bus duct shall be subjected to routine tests as per relevant standard.

9.2 Wherever specified, temperature rise tests shall be carried out on a minimum 5 metre length bus duct of each rating.

9.3 The test shall be carried out in manufacturer’s works in presence of purchaser’s representative. In addition, the bus ducts shall be subjected to stage inspection at works and inspection at site for final acceptance.

9.4 These inspections shall, however, not absolve the vendor from his responsibility of making good any defect which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure - I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following descriptions written boldly
- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance
Item wise unit prices of spare parts shall be quoted.

11.2 Commissioning Spares
Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipment.
12.0 PACKING

12.1 The bus duct shall be properly packed before despatch to avoid damage during transport, storage and handling. It shall be wrapped in polythene bags to make it waterproof. An additional wrapping with bitumen paper shall also be provided to make it completely waterproof before the equipment is packed in wooden crates.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
## ANNEXURE - I

### DOCUMENTATION FOR BUS DUCT

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Description</th>
<th>Documents Required (Y / N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>With Bid</td>
</tr>
<tr>
<td>1.</td>
<td>General arrangement for each bus duct showing the complete layout.</td>
<td>N</td>
</tr>
<tr>
<td>2.</td>
<td>Design calculations</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>a) Bus bars sizing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) Flexible sizing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Temperature Rise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d) Support Span</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Specification sheet &amp; Technical Particulars</td>
<td>N</td>
</tr>
<tr>
<td>4.</td>
<td>Switchgear end termination details for each rating of bus duct.</td>
<td>N</td>
</tr>
<tr>
<td>5.</td>
<td>Transformer end termination details for each rating of bus duct.</td>
<td>N</td>
</tr>
<tr>
<td>6.</td>
<td>Assembly drawing of rigid bends.</td>
<td>N</td>
</tr>
<tr>
<td>7.</td>
<td>Assembly drawing of bends with flexible</td>
<td>N</td>
</tr>
<tr>
<td>8.</td>
<td>Assembly drawing of straight run</td>
<td>N</td>
</tr>
<tr>
<td>9.</td>
<td>Transposition chamber details</td>
<td>N</td>
</tr>
<tr>
<td>10.</td>
<td>Installation, operation &amp; maintenance manual</td>
<td>N</td>
</tr>
<tr>
<td>11.</td>
<td>Test Certificates</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Type</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>ii) Routine &amp; others</td>
<td>N</td>
</tr>
<tr>
<td>12.</td>
<td>Guarantee Certificates</td>
<td>N</td>
</tr>
<tr>
<td>13.</td>
<td>List of spare parts</td>
<td>N</td>
</tr>
</tbody>
</table>

### Note:

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
TECHNICAL SPECIFICATION

SHEET STEEL DISTRIBUTION BOARDS
## Contents

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<td>DOCUMENTATION FOR SHEET STEEL DISTRIBUTION BOARDS</td>
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</tbody>
</table>
1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of Sheet Steel Distribution Boards.

1.2 This standard shall be read in conjunction with relevant part of Design Philosophy – Electrical.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment shall comply with the latest issue of the following Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

- IS: 8623 - Specification for low voltage switchgear and control gear assemblies.
- IS/IEC:60947 - Specification for Low-voltage Switchgear and Control gear
- IS: 10118 - Code of practice for selection, installation and maintenance of switchgear and control gear.

Various components housed in the distribution board shall conform to the Indian Standard Specification as mentioned against the component details.

2.2 The design and operational features of the equipment offered shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions
These shall be as indicated in Design Philosophy – Electrical.

3.2 System Details
These shall be as indicated in Design Philosophy – Electrical.

4.0 OPERATING REQUIREMENTS

The distribution board shall be suitable for operating at the specified rating continuously with the specified voltage and frequency variations under the ambient conditions, without exceeding the permissible temperature rise and without any detrimental effect on any part.

5.0 DESIGN AND CONSTRUCTIONAL FEATURES

5.1 General

5.1.1 The distribution board shall consist of an assembly of a series of floor mounting, identical, metal clad, dead front type panels of unitized design. The panels shall be placed side by side to form a compact assembly and shall be extensible on either side.

5.1.2 The complete assembly shall be dust, damp and vermin proof having minimum degree of protection equivalent to IP-52 as per IS/IEC:60947.

5.1.3 The frame work of the cubicles shall be of bolted/welded construction. The minimum thickness of steel shall be 2 mm for load bearing members, 1.6 mm for non-load bearing
members and 3 mm for base channel. The doors and covers shall be fabricated from cold rolled sheet steel. Suitable reinforcement, wherever necessary, shall be provided.

5.1.4 The door hinges shall be concealed type.

5.1.5 All external hardware shall be cadmium plated/zinc passivated. The hardware for fixing the removable parts shall be provided with retaining devices.

5.1.6 The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets. Gaskets without any discontinuity shall be preferred. Gaskets shall be held in position in groove of shaped sheet steel work or these shall be of U type. Adhesive cement, if used, shall be of good quality so that the gaskets do not come off during service.

5.1.7 All the components shall be accessible for inspection and maintenance without the necessity for removal of the adjacent ones. In case of single front design all components shall be accessible from the front for maintenance and back opening doors/openable covers for maintenance shall not be acceptable.

5.1.8 The layout of the components inside a module shall be liberal to facilitate maintenance and the interconnection of wiring between the components shall not be subjected to any undue stress at the bends.

5.1.9 Mounting height of components requiring operation and observation shall not be lower than 300 mm and higher than 1800 mm.

5.1.10 Inter panel barriers shall be provided.

5.1.11 Adequate arrangement for earthing shall be provided to safeguard the operator or other personnel from electric hazards under all conditions of operation.

5.2 Panel Arrangement

5.2.1 The distribution board shall be non-drawout type in single front configuration.

5.2.2 Each Panel shall have its horizontal bus-bar chamber running on the top with multi-tier module units in the centre and having vertical bus-bar chamber and cable alley on either side.

5.2.3 The modules shall be enclosed on all sides and shall be so arranged that larger ones are placed at the bottom portion of the panel. Fixed type modules shall be at least 300 mm from the base channel.

5.2.4 The number of modules in the panel shall not exceed six for motor starter feeders and eight for switch fuse/MCB/MCCB feeders. The minimum size of module shall be 300 mm and 200 mm for starter and switch fuse feeders. The incomer and bus coupler module sizes for ratings up to 400 A shall be half the panel size. For higher ratings they shall be housed in single panel.

5.2.5 The module door shall be so interlocked that it shall not be possible to open the door with switch in closed position. Defeat interlock facility shall be provided.

5.2.6 The relay, meters, switches and lamps shall be flush mounted. All components of one module shall be mounted on the same module on a rigid sheet steel chassis. A 20 mm dia. rotating knob on the door shall be provided for closing and opening.

5.3 Bus Bars and Connections
5.3.1 The bus-bar shall be suitable for the supply system. The bus-bar and connections shall be made of electrolytic copper or high conductivity aluminium alloy conforming to Grade E91E of IS: 5082.

5.3.2 The bus-bar shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding the temperature of 90ºC. The bus-bars shall also be designed to withstand the system fault current for 1 second without exceeding the temperature of 200ºC for bare aluminium and 250ºC for bare copper. The minimum acceptable size of bus-bars shall be 250 sq. mm (Al). Calculation for the bus-bar sizing shall be furnished along with the offer.

5.3.3 In case of double front arrangement of distribution boards, different sets of vertical bus-bars shall be provided. The vertical bus-bars shall be PVC sleeved or shrouded by insulating barriers which shall have cut-outs to permit entry of power wires. It shall be possible to remove the shroud for inspection and maintenance. Neutral-bars shall be provided in this chamber.

5.3.4 Horizontal bus-bars shall be of same cross-section throughout. Stepped bus-bars shall not be acceptable.

5.3.5 All bus-bars shall be arranged and colours coded according to IS: 5578/11353.

5.3.6 The horizontal bus-bar shall run in a separate bus chamber located at the top shall have separate screwed cover for inspection purpose.

5.3.7 The bus-bars shall be rigidly supported at equal intervals to withstand maximum short circuit stresses. The supports shall be of moulded construction with built in anti tracking barriers. The support material shall be of fibre glass reinforced thermosetting plastic.

5.3.8 All joints shall be suitably treated to avoid oxidation of contact surfaces and bimetallic corrosion. A minimum of two bolts with spring washers shall be used for horizontal bus-bar joints.

5.3.9 Horizontal bus bars shall be insulated with heat shrinkable PVC sleeves of reputed makes. Insulating shrouds shall be provided for all joints of insulated bus-bars.

5.4 Clearance and Creepage Distances

5.4.1 The clearance and creepage distances shall not be lower than the values specified below:

i) Minimum clearance between two live conductors -- 20 mm

ii) Minimum clearance between live part and accidentally dangerous part -- 20 mm

iii) Minimum creepage distance -- 28 mm

5.4.2 The clearances and the creepage, as specified above, shall definitely be maintained in the bus-bar system. Provision of bus-bar insulations, separator or barriers shall not be considered to reduce the clearance from the values specified above.

5.4.3 At the termination points in the equipment, e.g. switches, contactors, thermal relays, etc. it is realized that above clearance shall not always be possible to be maintained. All such points where above clearance are not possible to be maintained shall, therefore, be insulated or taped.

5.5 Insulation

5.5.1 The insulation used shall be non-hygroscopic and shall be of porcelain, Epoxy- resins or fibre glass moulded with plastic. It shall be of adequate electrical and mechanical strength to give trouble free service during normal operation and short circuit conditions.

5.5.2 The insulation shall be treated suitably to withstand the tropical conditions and atmospheric pollution.
5.6 **Power Wiring**

5.6.1 The connections from bus-bar including neutral to individual units on the modules shall consist of PVC insulated flexible copper cable or tapped copper strip.

5.6.2 The power wiring size shall be decided based on the rating of the switch, after using a rating factor of not more than 50% over the current rating in free air. In any case the minimum size of power wiring shall not be less than 4 sq. mm copper.

5.6.3 The size of connection from incomer to horizontal bus-bar and from horizontal bus-bar to bus coupler shall not be less than the size adopted for horizontal bus-bar.

5.7 **Control Wiring**

5.7.1 The switch board shall be completely factory wired and ready for external connections.

5.7.2 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables of 1100 Volt grade. The size of wires shall be as follows:

- C.T. Circuit -- 2.5 sq. mm
- V.T. and Control Circuits -- 1.5 sq. mm

5.7.3 All wiring shall be provided with dependent both end marking as per IS: 5578. Numbered ferrules, reading from the terminals outwards, shall be provided at both ends of all wiring for easy identification. These shall be interlocking type plastic ferrules.

5.7.4 Control wiring circuits, fed from a supply common to a number of feeders, shall be so protected that failure of a circuit in one feeder does not affect the operation of the other feeders.

5.7.5 The wiring to the equipment mounted on the doors shall be carried out with flexible multi strand copper conductor cable and supported so that opening of the door, there is no undue strain on wire leads.

5.7.6 The control cables shall be neatly arranged and properly supported.

5.8 **External Cable Termination**

5.8.1 All power and control cables shall enter the distribution board from the bottom. Sufficient space shall be provided for ease of connection and termination of cables.

5.8.2 All cables shall be of 1.1 KV grade PVC insulated armoured and PVC sheathed except for single core cable which shall be unarmoured. The number and sizes of cable shall be as indicated in Feeder details.

5.8.3 Compression type cable glands along with the cable lugs as required shall be provided for termination of cables.

5.8.4 The cable glands shall be of rolled Aluminium heavy duty double compression type and shall be mounted on a removable gland plate, provided at a minimum height of 75 mm from the bottom of the distribution board. Two numbers spare knockouts of size 20 mm shall also be provided on the gland plates for future use.

5.8.5 For all power cables crimped type aluminium lugs for aluminium cables and tinned copper lugs for copper cables shall be provided.

5.8.6 The terminal blocks shall be pressure clamp type up to 35 sq. mm cable and bolted lug type for higher sizes of cables. These shall be protected type and rated for 1100 Volts service. The minimum current rating of terminal block shall be 16 Amp. The construction shall be such that after the connection of cables by means of lugs, necessary clearance and creepage distance are available.

5.8.7 Where more than two cables in parallel are required to be terminated, a system of bus links shall be provided with adequate clearance and spacing.
5.8.8 Suitable clamps to support the vertical run of cables shall be provided.

5.8.9 The terminal block shall be grouped according to circuit functions and suitably numbered. 20% extra terminals shall be provided in the terminal block.

5.8.10 For power connections, suitable marking on the terminals shall be provided to identify the phases.

5.9 **Feeder Details**

5.9.1 The requirements of incomer, bus coupler and outgoing feeders shall be as indicated in the single line diagram, feeder details and corresponding schematic diagram.

5.9.2 The bus coupler shall be so located that it is possible to maintain half of the bus-bars while the other half is still alive. Complete segregation of bus-bar connections to bus coupler shall be provided.

5.9.3 Castle key type mechanical interlocks shall be provided between incomers and bus section modules to avoid paralleling of incomers. In addition padlocking facilities shall be provided in OFF position.

5.9.4 Single phase loads shall be distributed as far as possible on all the three phases.

6.0 **COMPONENT DETAILS**

The components shall conform to type of co-ordination C as per IS/IEC:60947. Makes of all components shall be subject to owner’s / consultant’s approval

6.1 **Moulded Case Circuit Breakers**

6.1.1 The circuit breaker shall conform to IS/IEC:60947 and shall be of P2 category having rupturing capacity as per system requirement.

6.1.2 The circuit breaker shall be provided with spring assisted quick make quick break type manually operated trip free mechanism, mechanical ON/OFF position indicators, thermal tripping devices of inverse characteristics, instantaneous short circuit tripping devices and necessary auxiliary and alarm switches. The MCCB cubicle shall be provided with service, test and isolated position and automatic safety shutter.

6.1.3 The thermal and short circuit tripping device shall be adjustable type.

6.1.4 When used for motor circuit shunt trip devices shall be provided and the let through power of controlling MCCB shall be lower than the respective contactor.

6.1.5 In addition, under voltage trip shall be provided, if specified.

6.2 **Switches**

6.2.1 The switches shall be Motor duty type AC23 category and shall comply with the requirements laid down in IS/IEC:60947. Switches up to 63 Amps shall be rotary type and those of 100 Amp and above shall be link type.

6.2.2 ‘ON’ and ‘OFF’ positions of the switches shall be indicated on the panel. Provision shall be made to lock the switch in the ‘OFF’ position.

6.2.3 The fixed contacts shall be shrouded and the contacts shall be silver plated.

6.2.4 Two Pole switches shall also isolate the neutral circuit along with phase circuit.

6.3 **Fuses**

The fuses shall be of non-deteriorating HRC cartridge link type and conform to IS: 13703. They shall be suitable for the load and the service required in the circuit.

6.4 **Air Break Contactors**
6.4.1 The Air Break Contactor shall be of AC3 category unless otherwise specified, conforming to IS/IEC:60947 and flapper type. Gravity operated contactors are not acceptable.

6.4.2 The dropout voltage shall not exceed 65% of rated voltage.

6.4.3 Each contactor shall be provided with auxiliary contacts as required. The rating of the auxiliary contacts shall be 5 Amps. AC or 1 Amp DC at the specified control voltages. The spare auxiliary contacts shall also be wired terminal block.

6.5 **Bimetal Thermal Overload Relays**

6.5.1 The contactor shall be provided with three pole bimetal thermal overload relays unless otherwise specified. The bimetal relays shall be of suitable range, ambient temperature compensated and shall be separate mounting type. They shall be adjustable through graduated scale and shall be provided with changeover contact.

6.5.2 Bimetal relays shall conform to IS: 3231 and shall have built in single phasing preventor.

6.5.3 The bimetal relays shall be provided with a manual reset device resetable after opening the cubicle door. Auto reset thermal relays are not acceptable.

6.6 **Current Transformers**

6.6.1 The current transformers shall conform to IS: 2705.

6.6.2 Current Transformers shall be Class-F insulated and vacuum impregnated. The Current Transformers shall be rigidly mounted and shall be easily accessible for maintenance and testing.

6.6.3 The Current Transformers shall be of 7.5 VA output. The output shall be adequate for the instrument and metering duties involved with sufficient margin. The Current Transformers shall have the accuracy Class-1 for the metering duty.

6.6.4 All the Current Transformers shall be provided with terminals and shorting links. One of the terminals of C.T. shall be earthed. The polarity of the C.T. shall be clearly marked.

6.6.5 The C.T.s shall be capable of withstanding momentary open-circuit on the secondary side without injurious effects.

6.7 **Instruments and Meters**

6.7.1 All instruments shall be flush mounting type with square face and shall be tropicalized and dust tight.

6.7.2 The size of the instruments shall be 96 mm x 96 mm for full and half size modules and 72 mm x 72 mm for lower size modules.

6.7.3 Dials shall be parallax free with scale marked in black on white background and shall be suitable for direct reading.

6.7.4 Zero adjusters shall be provided for operation from the front of the cases.

6.7.5 All ammeters and voltmeters shall have 0 - 240º scale moving iron spring controlled type and of Class 1.5 accuracy as per IS: 1248. The scale range of the ammeter and voltmeter shall be as indicated in the feeder details.

6.7.6 In case of motor feeders, the ammeter shall be graduated uniformly upto C.T. primary current and with a compressed end scale upto 6 times the C.T. primary current. Red pointer shall be provided, which can be adjusted at site for indicating full load current.

6.7.7 KWH meter shall be 3 phase 4 wire type. These shall conform to the requirements of relevant IS and shall be C.T. operated. The current coil shall be rated for 5 Amp.

6.7.8 All kWh meters shall be provided with test blocks for current and voltage coils for testing them at site without interrupting their recording while in service.
6.8 Push Button and Control Switches

6.8.1 The switches and push buttons shall conform to utilization category AC 11/DC 11 as per IS/IEC:60947. The contact shall be rated to make, break and carry inductive current of 5 Amp. at 415 V AC and 1 Amp at 220 V DC.

6.8.2 The control switches shall be spring return rotary type unless otherwise specified and provided with pistol grip type handle. The control switches for circuit breakers shall be additionally fitted with lost motion devices and sequencing devices.

6.8.3 The selector switches shall be stay-put rotary type and provided with oval shape handles.

6.8.4 The push buttons shall be of momentary contact spring loaded type with a set of normally close and open contacts. The push button for ‘Start’ shall be shrouded type and coloured green, stop push button shall be un-shrouded type and coloured red and other push buttons shall be un-shrouded type coloured black. The fixing ring shall be metallic white.

6.8.5 Emergency stop push buttons, if specified, shall be lockable in pushed position.

6.9 Miniature Circuit Breakers

6.9.1 The miniature circuit breakers shall conform to IS: 13032 and shall be of duty category M-9.

6.9.2 It shall be provided with overload and short circuit protective devices in a heat resistant housing.

6.9.3 A certificate of short circuit rating and current time tripping curve shall be furnished alongwith the offer.

6.10 Signal Lamps

6.10.1 Signal lamps shall be provided to indicate the various circuit conditions as shown in scheme drawings. The colour of the lamps for various functions shall be as follows:

<table>
<thead>
<tr>
<th>Colour</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Switch/Contactor closed.</td>
</tr>
<tr>
<td>Green</td>
<td>Switch/Contactor open.</td>
</tr>
</tbody>
</table>

6.10.2 The lamps shall be LED type having lumen output 200 milli candela in axial direction.

6.10.3 It shall be possible to remove the globe from outside for replacement of lamps.

7.0 ACCESSORIES

7.1 The supplier shall include the following accessories.

-- Fuse Puller.

-- Test plug for kWh meters.

7.2 Space Heater

Each vertical section shall be provided with a thermostatically controlled space heater, rated for 240 V, 50 Hz and controlled through double pole miniature circuit breaker.

7.3 Name Plates

7.3.1 The distribution board shall have large name plate on the top to indicate its name and designation.

7.3.2 Each feeder shall be provided with name plate. Each single front panel shall have name plate both in front and back.

7.3.3 All control switches, push buttons, lamps etc. shall have functional identification labels.

7.3.4 Name plate shall be of black perspex with white engraving and of minimum 3 mm thick.
7.3.5 Any other accessories required, but not specified shall also be supplied to make the distribution board complete in all respects to ensure safe and proper operation.

8.0 PAINTING

8.1 The enclosure after degreasing, pickling in acid, cold rinsing phosphatising, passivating etc. shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 Unless otherwise specified, the finishing shade shall be light grey Shade No.631 as per IS: 5.

8.5 One litre of paint shall be supplied along with each board for touch up at site.

9.0 TESTS AND INSPECTION

9.1 The distribution boards shall be subjected to routine test as per IS: 8623.

9.2 Additional tests, wherever specified, shall be carried out.

9.3 All the above tests shall be carried out in presence of purchaser’s representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.

9.4 These inspections shall however, not absolve the vendor from his responsibility for making good any defect which shall be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied unless otherwise specified.

10.2 All drawings and documents shall have the following description written boldly:
   - Name of client
   - Name of consultant
   - Enquiry / Order Number with plant / project name
   - Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of spare parts shall be quoted.

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipments.

12.0 PACKING

12.1 The distribution board shall be properly packed before despatch to avoid damage during transport, storage and handling.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.
12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
### ANNEXURE - I

#### DOCUMENTATION FOR SHEET STEEL DISTRIBUTION BOARDS

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**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
# TECHNICAL SPECIFICATION

## LIGHTING SUB DISTRIBUTION BOARDS
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1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well packed condition of lighting sub distribution boards.

1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of the following Indian Standards. Equipment complying with equivalent IEC standards shall also be acceptable.

- IS/IEC:60947 - Low voltage switchgear and control gear
- IS: 8623 - Specification for low voltage switchgear and control gear assemblies

2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of the Indian Electricity Rules and other relevant statutory acts and regulations. The supplier shall, wherever necessary, make suitable modification in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy - Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy - Electrical.

4.0 OPERATING REQUIREMENTS

The lighting sub-distribution boards shall be suitable for operating continuously under the ambient conditions and with the voltage and frequency variations, without exceeding the specified temperature rise and without any detrimental effect on any part.

5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

5.1 The lighting sub distribution boards shall be fabricated out of 2.5 mm thick cold rolled sheet steel and shall be suitable for mounting on wall/structure. These shall have dust and vermin proof construction conforming to IP-54 as per IS/IEC:60947. For outdoor installation, the enclosure shall conform to IPW-55. Suitable canopy made out of 2 mm thick Aluminium sheet shall be supplied along with the board.

5.2 The miniature circuit breakers shall be so mounted inside the enclosure that their operating knobs project outside for easy operation. The cut-out for the knobs on the enclosure shall be lined with gasket for dust proofness. For further protection against ingress of dust, the portion where the knobs have protruded out, shall be provided with another external front cover, internally hinged at the top, gravity operated and with a knurled knob at the bottom. The external cover shall be flushed with the main cover. Continuous neoprene gasket shall be provided to make the board completely dust and weather proof.

5.3 All external hard ware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel cadmium plated or zinc passivated.
5.4 The sub-distribution boards to be located indoors shall have top entry arrangement for outgoing cables and bottom entry for incoming cable. However for outdoor locations, all cable entries shall be from the bottom only.

5.5 Three phase and neutral bus bar system of adequate size shall be provided to which all outgoing and incoming MCB’s shall be connected.

5.6 The internal wiring shall be carried out by means of single core PVC insulated 2.5 sq. mm stranded copper conductor cables.

5.7 Two earthing terminals outside the board shall be provided.

5.8 Suitable label inscription consisting of black perspex with engraving for the board and circuit nos. of all outgoing feeders shall be provided. The label inscription of the board shall contain description and code no. The circuit nos. of outgoing feeders shall be serially indicated as 1L, 2L.........17L, 18L.

5.9 The board shall be complete with terminal block, cable glands, cable lugs and other accessories as specified.

6.0 SPECIAL FEATURES FOR FLAME PROOF LIGHTING SUB DISTRIBUTION BOARDS

6.1 The enclosure shall be in addition of flame proof execution as per IS: 2148.

6.2 The enclosure group and temperature class shall be as indicated in Design Philosophy – Electrical.

6.3 The enclosure shall be of cast iron/cast Aluminium alloy (4600 as per IS: 617).

6.4 Cables shall enter the terminal chamber through flame proof compression type cable glands. From terminal chamber to the main enclosure connection shall be made through bushings. Direct entry of external cables into the main enclosure shall not be accepted.

6.5 The sub-distribution board shall be of 6 way type.

6.6 Individual earth terminals shall be provided for the earth conductor of the outgoing cables beside the phase and neutral terminals.

6.7 The sub-distribution board must be certified by Central Mining Research Institute, Dhanbad or other statutory authority for use in specified hazardous area.

7.0 COMPONENT DETAILS

7.1 The lighting sub-distribution board shall be wired and have components as per SD-8083 (copy attached).

7.2 Miniature Circuit Breaker (MCB)

The MCB shall be of duty category M-9 and shall conform to IS/IEC:60898-1:2002. It shall be provided with overload and short circuit protective devices. MCB shall be of C Curve Type.

7.2.1 The incoming MCB’s or switches shall be of triple pole and switched neutral type and outgoing MCB’s of single pole and switched neutral type, single phase earth leakage protection in each phase of the incomer shall be provided.

7.3 Terminal Block

Pressure clamp type terminal blocks shall be provided both for incoming and outgoing cables. The rating of the terminal block shall be at least 1.5 times the rating of the MCB.

7.4 Cable Glands

Heavy duty double compression type Aluminium cable glands suitable for PVC insulated, armoured and PVC sheathed 1.1 KV grade incoming and outgoing cables shall be provided.
8.0 **PAINTING**

8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti rust paint followed by two coats or anticorrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 The finishing shade shall be light grey shade no.631 as per IS: 5.

9.0 **TESTS AND INSPECTION**

9.1 All the lighting sub-distribution boards shall be subjected to routine tests as per IS: 8623.

9.2 Additional tests, wherever specified, shall be carried out on one lighting sub-distribution board of each type.

9.3 The above mentioned tests shall be carried out in the manufacturer’s works in the presence of purchaser’s representative. In addition, the equipment shall be subjected to stage inspection at works and inspection at site for final acceptance.

9.4 The purchaser’s inspection shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

10.0 **DRAWINGS AND DOCUMENTS**

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following description written boldly.
   - Name of client
   - Name of consultant
   - Enquiry / Order Number with plant / project name
   - Code No. and Description

11.0 **SPARES**

11.1 Spares for operation and maintenance

   Item wise unit prices of spare parts shall be quoted.

11.2 Commissioning Spares

   Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipment.

12.0 **PACKING**

12.1 The equipment shall be properly packed to safeguard against weather conditions and handling during transit. It shall be wrapped in polythene bags and an additional wrapping of bitumen paper shall also be provided to make it completely water proof before the equipment is packed in wooden crates.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

13.0 **DEVIATIONS**

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
## ANNEXURE - I

### DOCUMENTATION FOR LIGHTING SUB DISTRIBUTION BOARDS

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Y - Yes, N - No
TECHNICAL SPECIFICATION
INDUCTION MOTOR
# TECHNICAL SPECIFICATION - INDUCTION MOTOR

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1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of medium voltage and high voltage induction motors.

1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS-325 and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of the Indian Electricity Rules and other relevant Statutory Rules & Regulations. The supplier shall, whenever necessary, make suitable modification in the equipment to comply with the above mentioned rules.

2.3 Flame proof motors shall, in addition, comply with the requirements laid down in IS: 2148.

2.4 Increased safety motors shall, in addition, comply with the requirements laid down in IS: 6381.

2.5 Motors with type of protection “n” shall, in addition, comply with the requirements laid down in IS: 9628.

2.6 Wherever any requirement laid down in this standard differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

The ambient conditions shall be as indicated in the Design Philosophy - Electrical.

3.2 System Details

3.2.1 The details of power system to which the motors will be connected shall be as indicated in the Design Philosophy - Electrical.

3.2.2 The motors shall be suitable for connection to a power system where transient disturbances are very likely to occur. During the transient disturbances, voltage of the system may completely disappear and return in a short time with the motors still running and connected. Under this condition, the return of voltage may occur at such an instant that the induced e.m.f. in the motor is in phase with the applied voltage giving rise to current surges which may reach a value equal to 1.6 times the starting current and also cause transient torques of large magnitudes.

4.0 GENERAL DESIGN FEATURES

4.1 Enclosure

4.1.1 The enclosure of motors for indoor and outdoor services shall be IP-54 and IPW-55 respectively as per IS/IEC:60529, unless otherwise specified.

4.1.2 Motors for outdoor service shall be provided with special seals for the enclosure, joints, bearing housing, terminal boxes etc. so that no extra protective covering for ingress of water shall be required.

4.1.3 Vertical motors for outdoor installation shall be provided with a rain protective hood.
4.1.4 All external hardware shall be zinc passivated or cadmium plated.

4.1.5 The enclosure shall be provided with threaded metallic plug to permit drainage of condensed water from the inside.

4.2 Cooling

4.2.1 All motors shall be totally enclosed fan cooled conforming to IC-0141 as per IS: 6362 unless otherwise specified.

4.2.2 In case of CACA construction, the same shall conform to IC-0161 as per IS: 6362.

4.2.3 In case of CACW construction, the same shall conform to ICW 37A 91 as per IS: 6362.

4.2.4 Wherever service conditions are such that corrosive agents are present in the surroundings, the following materials of construction for cooling tubes shall be adopted, unless otherwise specified.

For CACA motor - Aluminium tubes having minimum thickness of 1.6 mm

For CACW motor - Low carbon alloy steel

4.2.5 In case of CACW motors, the cooling tubes and flanges shall also be suitable for the cooling water analysis. Trays shall be provided for collection of leaking water with arrangement for its drainage.

4.2.6 The cooling fans shall be suitable for bidirectional rotation of motors. These shall be fastened to the motor shaft by means of compensating rings or will be balanced independent of the motor. Guide key or reference points shall be supplied to prevent wrong assembly. The cooling air shall be sucked from the non-driving end.

4.2.7 The cooling fans shall be made of non-sparking materials such as cast Aluminium (LM-6 alloy) / cast iron.

4.3 Direction of Rotation

4.3.1 Motors shall be suitable for both directions of rotation. In case of any design limitation, the same shall be indicated in the offer.

4.3.2 In either case, a plate showing the direction of rotation corresponding to the phase terminal markings shall be fitted at the driving end shield of the motors.

4.4 Stator

4.4.1 The stator laminations shall be made from suitable magnetic sheet iron varnished on both sides. Where ventilation is required, these shall be arranged in suitable packs, each pack being separated by spacers to form ventilating ducts for circulation of air.

4.4.2 The slot shall be open type with coils so arranged that the coils can be easily removed for inspection and repair.

4.5 Rotor

4.5.1 The rotor shall be of squirrel cage construction, unless otherwise specified.

4.5.2 For small motors, the squirrel cage shall preferably be of pressure die-cast construction. For large motors, the rotor bars and the end rings shall be of copper or copper alloy. The bars shall be firmly placed in slots to prevent vibration during start up / locked rotor condition. Conductor ends shall be securely fixed to the end rings using the latest brazing techniques. Retaining rings shall be provided for high speed machines for the end rings. The rotor cage shall be designed for the required starting and duty cycles.

4.5.3 Wherever wound rotor is specified, the windings shall have the same features as detailed for the stator windings. The rotor voltage shall not exceed the stator voltage.
4.5.4 The rotor shall be dynamically balanced and shall rotate perfectly with no preferential stop points. The rotor shall be constructed such as to allow the removal or addition of material for balancing.

4.5.5 The rotor shaft shall be electrically and magnetically so balanced that the induced shaft voltage does not exceed 200 millivolt. Otherwise the bearing housing at non-driving end shall be insulated for 2 KV.

4.6 Windings and Insulation

4.6.1 The motor coils shall be made out of insulated electrolytic grade copper conductor. Successive coils shall be connected by accessible joints, well brazed and finished smooth to prevent damage to insulation.

4.6.2 The motors shall be insulated assuming the power system neutral as isolated.

4.6.3 All motors shall be insulated with F insulation with tropical and fungicidal treatments.

4.6.4 Wherever class F insulation is specified, the windings shall be easily replaceable type and the temperature rise shall not exceed that of class B insulation.

4.6.5 The winding coils shall be dried, properly impregnated with suitable varnishes to withstand the site conditions and properly baked. At least two additional impregnations and baking shall be applied to the assembled stator coil, making a total of three impregnations and baking. Finally the windings shall be painted with special anti-acid and anti-alkali paints to withstand the site conditions.

4.6.6 The windings shall be well brazed and capable of withstanding thermally and mechanically the transient disturbances specified under clause 3.2.2.

4.6.7 Lead-in wire between the windings and the outside terminals shall be made through bushings in H.V. motors. For M.V. motors, heat resistant insulated conductors shall be used as lead-in wire.

4.6.8 The windings shall be star connected for high voltage motors and delta connected for medium voltage motors.

4.7 Slip Rings and Brushes

4.7.1 Slip rings shall be located in the non-driving side. The material of construction shall be copper alloy. The slip rings and the brush gear shall be cooled by the motor cooling fan.

4.7.2 For explosion proof motors, the slip rings and brush gear shall be housed in a flameproof housing. In case this is not possible, the housing shall be pressurised type with flameproof pressure switch for interlocking with the motor. In either case, glass covers shall be provided for inspection.

4.7.3 The starting rheostats shall be designed for intermittent duty and rated for 10 minutes. Where speed regulation is required, the rheostats and the controllers shall be suitable for such duty and be continuously rated. Auxiliary contacts shall be provided on the controllers for connections to the motor supply controls to prevent wrong operations during starting.

4.8 Bearings

4.8.1 All motors shall be provided with bearings suitable for the application. The bearings must be guaranteed to ensure a smooth operation and a life not shorter than 30,000 hrs.

4.8.2 Where external thrusts are specified, the motors shall be fitted with special roller thrust bearings capable of withstanding the specified thrust. In such cases, the guaranteed life of the bearings shall not be less than 20,000 hours.

4.8.3 The bearing housing shall be effectively sealed against ingress of dust and water and creep age of lubricants along the shaft.
4.8.4 The bearing shall be suitable for both directions of rotation of the motor.

4.8.5 All motors shall be provided with on-line grease lubrication arrangement for both DE and NDE side bearings except for motors of frame size 112 and less and flange mounted M.V. motors. The arrangement shall be complete with grease nipple and drain plug located at convenient locations.

4.8.6 All oil lubricated bearings shall be fitted with oil level indicator and resistance temperature detector/dial type thermometer with alarm and trip contacts.

4.8.7 Self cooled bearing system shall be preferred.

4.8.8 The manufacturer shall specify the type of lubricant and the time interval of lubrication for the bearings of each motor.

4.8.9 The bearing temperature shall not exceed 90ºC for grease lubricated bearings and 70ºC for oil lubricated bearings.

4.8.10 Wherever shaft end-play has been specified, the bearings shall be capable of providing the specified end-play.

4.9 Terminal Box

4.9.1 All the terminal boxes shall have identical degree of protection as that of the motor.

4.9.2 The power terminal box shall be mounted on the right hand side of the motor as viewed from the coupling end. For M.V. Motors, design of terminal boxes shall be such that it may be possible to arrange top/bottom/side entry of cables at site.

4.9.3 The power terminal boxes shall be as follows:
   a) For H.V. motors - Phase segregated type capable of with standing the system fault level for 0.2 Sec. or more.
   b) For M.V. motors - Manufacturer’s standard box with epoxy or SRBF moulded terminal board.

4.9.4 The mounting arrangement of power and neutral side terminal boxes for HV motors shall be identical so that it shall be possible to interchange the boxes at site.

4.9.5 In case of H.V. motors, all the six leads of the motors shall be taken out, three on one side and three on the other side to separate terminal boxes. However, neutral shorting link shall be provided on the neutral box for star connection.

4.9.6 In case of M.V. motors, all the six leads of the motors shall be taken out to a common terminal box. Shorting links for delta connections shall be provided in the terminal box for motors 112 frame and above.

4.9.7 For increased safety motors and for motors with type of protection “n”, the terminals shall be provided with positive locking device so that they do not become loose during normal operation.

4.9.8 The power terminal boxes shall have adequate clearances in between the terminals and also between the terminals and cable gland for proper termination of cables. Where more than one cable is required to be terminated in parallel, the spacing in the box shall be adequate for easy termination.

4.9.9 Separate terminal boxes shall be provided for connection of power, control and space heater cables.

4.9.10 All terminal boxes shall be complete with heavy duty double compression type cable glands and lugs/connectors to receive the external cables.

4.9.11 Where cross linked polyethylene cables are specified, the terminal box shall be suitably designed for proper termination of such cables.
4.9.12 The cable lugs shall be of tinned copper and suitable for crimping.

4.10 **Geared Motors**

Where geared motors are specified, the gears shall be oil lubricated, heavy duty as per AGMA class III and capable of transmitting the rated motor power continuously. They shall be capable of withstanding moderate shock loads having a service factor of 2 and the starting duties. They shall be silent and smooth in operation. Inspection glass shall be provided to indicate the oil level in the gear box.

**5.0 PERFORMANCE**

5.1 **Starting**

5.1.1 The motors shall be capable of being started direct-on-line, unless otherwise specified.

5.1.2 The starting torque of each motor shall be higher than the initial resisting torque of the driven load throughout the starting period even at a feeding voltage of 85% of the rated voltage for normal purpose motor and 80% of the rated voltage for special purpose motor.

5.1.3 The starting current of 415 V Motors shall not exceed the values indicated in IS: 12615. Also there shall be no further positive tolerance on the values of starting current.

The starting current of 11 KV & 3.3 KV motors shall not exceed 500% of FLC.

5.1.4 The motors shall be suitable for the following starting cycle:

a) With the motor at ambient temperature - 2 successive starts and 3rd start after 5 minutes.

b) With the motor at steady state load temperature - 1 immediate start and 2nd start after 5 minutes. This sequence shall be repeated in the next hour.

5.1.5 Speed switch shall be provided, wherever required, to fulfil the starting conditions.

5.2 **Locked Rotor Condition**

5.2.1 The locked rotor withstand time (t_E), under hot condition at 110% of rated voltage shall be more than the starting time of the motor coupled to the load even at the lowest stipulated starting voltage by 2 secs. for motors, having starting time up to 10 secs. and by 5 secs. for motors, having starting time more than 10 secs.

5.2.2 For increased safety motors, t_E under hot condition shall not be less than 10 secs. The value of t_E shall be determined in the presence of purchaser’s representative unless test certificate from an independent testing authority is submitted for similar motors. The time t_E and the locked rotor current shall be stamped on the name plate as well as indicated in the test certificates.

5.2.3 For deciding the time t_E in all cases, the temperature of the insulated stator and rotor shall not exceed the value stipulated under clause no. 5.4.3.

5.3 **Running**

5.3.1 All motors shall be continuous maximum rated (S1 duty as per IS: 325), unless otherwise specified.

5.3.2 The motors shall be capable of delivering the rated output without exceeding the specified temperature rise under the system voltage and frequency variation conditions.

5.3.3 The motors shall be suitable for running at the rated load for 5 minutes duration at 80% voltage and for 1 Sec. duration at 70% voltage, without exceeding the specified temperature rise.

5.4 **Temperature Rise**
5.4.1 The total temperature of the stator winding under full load running condition shall not exceed the values permissible for the specified insulation class. For increased safety motors, the total temperature shall be 10°C less than for normal motors.

5.4.2 For explosion proof motors, the maximum surface temperature shall not exceed the values applicable for temperature class of the hazardous gases / vapours present in the surrounding area. However for type 'n' motors, the maximum allowable temperature shall not exceed 200°C.

5.4.3 In case of starting and locked rotor conditions stipulated under clause nos. 5.1.4 and 5.2.1 respectively, the maximum temperature in the rotor shall not exceed the following values:

- For squirrel cage rotor: 300°C
- For wound rotor: As applicable to the insulation class
- For explosion proof motor: As per temperature class of the hazardous gases / vapours, without exceeding the above temperature as applicable

6.0 COUPLING DETAILS

6.1 Unless otherwise specified, all motors shall be coupled to the driven equipment through flexible coupling.

6.2 Normally the coupling half for the motor shaft shall be supplied by the driven equipment supplier. The coupling half shall be keyed on the shaft with a tapered joint or shrunk with a straight joint. For this purpose, the motor manufacturer shall coordinate all details of the coupling system with the driven equipment manufacturer, wherever required.

6.3 Where rigid coupling is specified, the motor shaft shall have the desired class of accuracy.

6.4 For all vertical flange mounted motors, the limitations on shaft extension, run out, perpendicularity and eccentricity, as required by the driven machine supplier shall be complied with by the motor supplier.

6.5 i) If the motor is to be coupled to a reciprocating pump or compressor requiring fluctuating torque, the motor supplier shall ensure that the inertia of the driving and driven machine assembly shall be such that the variation in the armature current shall not exceed ±66% of the rated current while delivering full load.

ii) The measurement of armature current shall be done with the oscillograph.

iii) The additional fly wheel, if any, shall be assembled at such a distance from the motor so as to allow easy inspection of the windings.

iv) All necessary coordination with driven equipment manufacturer shall be carried out by the motor manufacturer.

6.6 i) Wherever belt drive is specified, the motor supplier shall ensure that the shaft extension and the bearings are suitable for the duty specified.

ii) Unless otherwise specified, the slide rails for all belt driven motors shall be supplied by the motor manufacturer.

7.0 ACCESSORIES

The motors shall be complete with all the accessories.

7.1 Space Heaters
7.1.1 Space heaters rated for 240 V A.C. shall be provided to keep the winding dry for all high and medium voltage motors, except for motors rated below 30 KW which shall be suitable for space heating by connecting 24 V A.C to any of the two motor winding terminals.

7.1.2 The location of the space heaters shall be such as to allow easy access for inspection, maintenance and replacement.

7.2 **Name Plates**

7.2.1 The name plates shall be of stainless steel with letters embossed on them.

7.2.2 The name plate shall contain all the relevant details as per IS: 325 and in addition shall indicate the following:
   i) The description and code no. of motor
   ii) Degree of protection of enclosure
   iii) Temperature rise of windings under running condition
   iv) Designation of bearings
   v) Recommended type of lubricant and interval of lubrication
   vi) Direction of rotation
   vii) Mounting Arrangement

7.2.3 Flameproof motors shall have additional name plate containing relevant particulars as per IS: 2148.

7.2.4 Increased safety motors shall have additional name plate containing relevant particulars as per IS: 6381.

7.2.5 Motors with type of protection “n” shall have additional name plate containing relevant particulars as per IS: 9628.

7.3 **Embedded Temperature Detectors**

7.3.1 All high voltage motors shall be provided with 6 nos. of evenly distributed embedded resistance temperature detectors for measurement of winding temperature. These shall be located in positions at which the highest temperatures are likely to occur.

7.3.2 In addition, the high voltage motors shall be provided with
   i) 1 no. RTD for hot air temperature measurement
   ii) 2 nos. RTDs (1 on each side) for bearing temperature measurement of oil lubricated bearings. For grease lubricated bearings, RTD shall be provided only where specified

7.3.3 These RTDs shall be of platinum having 100 ohm resistance at 0ºC and temperature coefficient as 3.850 x 10⁻³.

7.3.4 The RTDs shall be 3 lead type having power frequency insulation level of 2KV.

7.3.5 The RTDs shall comply with the requirements laid down in IS: 2848.

7.4 **Dial Type Thermometers**

7.4.1 In high voltage motors, the measurement of hot air and bearing temperature (of oil lubricated bearings) by dial type thermometers shall be provided wherever specified.

7.4.2 The arrangement shall consist of a dial type of mercury-in-steel thermometer so mounted that its stem shall be located in the maximum temperature region.
7.4.3 The thermometer shall have two potential free contacts for alarm and trip.

7.4.4 All contacts shall be rated for 2 Amps. at 110 V D.C.

7.4.5 For bearing temperature measurement, separate thermometers shall be provided for each bearing.

7.4.6 For grease lubricated bearings, temperature measurement arrangement shall be provided only where specified.

7.5 **Oil Supply System**

7.5.1 For large sized motors, where forced oil lubrication system is considered, a common oil supply system for the motor and the driven equipment shall be provided by the driven equipment manufacturer.

7.5.2 However, the motor supplier shall quote separate price for the complete oil system of the motor.

7.5.3 The system shall be suitable for location near the motor.

7.5.4 The oil supply system for each motor shall include:
   i) 2 Nos. 100% rated motor driven pumps with motors
   ii) 1 No. oil tank complete with oil level gauge and thermometer
   iii) 1 No. oil cooler
   iv) 1 No. oil filter
   v) 1 No. differential pressure switch for filter
   vi) 2 Nos. pressure switches
   vii) Necessary piping
   viii) Necessary control and interlocks

8.0 **VIBRATIONS**

The motor vibrations measured at the bearings must not exceed the limits specified in IS: 12075.

9.0 **NOISE LEVEL**

The motor noise level shall not exceed 85 dB measured at a distance of 1 metre from the motor.

10.0 **PAINTING**

10.1 Enclosures of the motor and its accessories shall be painted with two coats of anti-rust paint and two coats of anti-corrosive paint after suitable pre-treatment.

10.2 Epoxy paint shall be used.

10.3 Unless otherwise specified, the finishing shade shall be light grey having shade No. 631 as per IS: 5.

11.0 **TESTS AND INSPECTION**

11.1 All motors shall be routine tested as per relevant standards.

11.2 Additional tests, wherever specified, shall be carried out on one motor of each rating.

11.3 For high voltage motors of each rating, polarization index test shall also be carried out.
11.4 All the above mentioned tests shall be carried out in the presence of purchaser’s representative. In addition, the motor shall be subject to stage inspection at works and inspection at site for final acceptance.

11.5 These inspections shall, however, not absolve the vendor from their responsibility for making good any defects which may be noticed subsequently.

12.0 PACKING
12.1 The motors shall be properly packed to safeguard against weather conditions and handling during transit.
12.2 The shaft shall be properly clamped / supported.
12.3 Rust inhibiting agents shall be applied to fittings and sliding surfaces.
12.4 All flanges shall be closed with blanking plates to avoid entry of foreign materials.
12.5 The loose pieces of the motor / spare parts / Instruments shall be separately wrapped in moisture resistant paper and marked with identification marks and name plate of the corresponding motors.
12.6 The packing box / crate shall include a copy of installation, operation and maintenance manual.

13.0 DRAWINGS AND DOCUMENTS
13.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.
13.2 All drawings and documents shall have the following descriptions written boldly:
   - Name of client
   - Name of consultant
   - Enquiry / order number with plant / project name
   - Motor Code No. and Description

14.0 SPARES
14.1 Spares for operation and maintenance
   Item wise unit prices of spare parts shall be quoted.
14.2 Commissioning Spares
   Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.
14.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.
14.4 All spare parts shall be identical to the parts used in the motors.

15.0 DEVIATIONS
15.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
### ANNEXURE - I

#### DOCUMENTATION FOR INDUCTION MOTORS

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<td>c) Load Vs Efficiency</td>
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<td>g) Starting current Vs Time</td>
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**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
TECHNICAL SPECIFICATION

INTERLOCKING SWITCH SOCKET AND PLUG
## CONTENTS

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1.0 SCOPE

1.1 The standard covers the technical requirements of design, manufacture, testing at works and delivery in well packed condition of interlocking switch socket and plug.

1.2 The standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS-4160/ IEC-309 and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of Indian Electricity Rules and other statutory acts and regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient conditions

These shall be as indicated in Design Philosophy - Electrical.

3.2 System details

These shall be as indicated in Design Philosophy - Electrical.

4.0 OPERATING REQUIREMENTS

The equipment shall be suitable for operating at the rated capacity continuously without exceeding the specified temperature rise and without any detrimental effect on any part.

5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

5.1 The switch socket shall be heavy duty industrial type. The interlocking arrangement shall be such that it is not possible to insert or withdraw the plug with the switch in ‘ON’ position.

5.2 The switch sockets shall have dust, hose and weather proof construction conforming to IPW55 as per IS/IEC:60947 and shall be suitable for outdoor use without any extra protection. All jointing surfaces shall be smoothly machined and of sufficient width to prevent ingress of dust. Further the covers shall be provided with continuous gaskets made of neoprene to prevent ingress of dust and moisture.

5.3 The enclosure of switch sockets and plugs shall be of cast aluminium alloy 4600 and suitable for fixing on wall / structure.

5.4 The enclosure shall be largely dimensioned in order to avoid temperature rise inside it which may damage the insulating materials and gaskets employed therein.
5.5 The insulating materials used shall be non-hygroscopic, mould proof and treated with suitable varnish to withstand the ambient conditions.

5.6 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm or above shall be of mild steel cadmium plated or zinc passivated.

5.7 Suitable arrangement for looping of cables from one switch socket to the other shall be provided. For switch sockets rated above 63A, looping shall be done from busbars and for switch sockets rated 63A and below, looping may be done from terminal block. Necessary terminals, cable glands and lugs for looping shall be provided. Also one no. The readed plug for each switch socket shall be supplied loose.

5.8 All the relevant information shall be provided on engraved name plate made of aluminium.

5.9 The enclosure shall be provided with two earthing terminals outside the body.

6.0 SPECIAL FEATURES FOR FLAME PROOF SWITCH SOCKET AND PLUGS

6.1 The enclosure shall be in addition of flame proof execution as per IS: 2148.

6.2 The enclosure group and temperature class shall be as indicated in Design Philosophy - Electrical.

6.3 Cable shall enter the terminal chamber through flame proof compression type cable glands. From the terminal to the main enclosure, the connection shall be made through proper bushings. Direct entry of external cables into the main enclosure shall not be accepted.

6.4 An additional earthing terminal inside the terminal chamber shall be provided.

6.5 Switch socket, plug and cable glands must be certified by the Central Mining Research Institute, Dhanbad or any other statutory authority for use in the specified hazardous area.

6.6 Further interlocking shall be provided so that the contacts cannot be energised when the plug and socket are separated.

7.0 COMPONENT DETAILS

Makes of all components shall be subject to owner’s / consultant’s approval

7.1 Air Break Switches

7.1.1 The switches shall be quick make, quick break rotary type and of utilisation category AC-23 as per IS/IEC:60947.

7.1.2 Switches shall be hand operated from outside the cover. The switch handle shall remain fixed to the front cover while removing the front cover.

7.2 H.R.C. Fuses

7.2.1 The sockets shall be provided with link type HRC fuses.

7.2.2 The fuses shall be capable of withstanding a short circuit current of 50 KA and shall be delayed action type conforming to IS: 13703. These shall be mounted on a shrouded base.

7.3 Socket Outlets
7.3.1 The socket outlet shall be located in the lower part of the enclosure and shall be provided with a threaded aluminium cover attached to the body with G.I. chain, to protect the socket after extraction of the plug. Spring loaded automatic shutter shall not be acceptable.

7.3.2 The socket contacts shall maintain satisfactory spring pressure and contact with the corresponding plug under normal service conditions.

7.3.3 The socket contacts shall be sunk well below the surface of the socket- outlets so as to make it impossible to be touched unintentionally.

7.3.4 An earthing contact shall be provided in the socket outlet which shall ensure making and breaking respectively of its contact with the earthing pin of the plug before and after making and breaking of the corresponding current carrying contacts.

7.4 Plugs

7.4.1 The plugs shall be so constructed so that these can be easily fitted in to the socket outlets.

7.4.2 These shall be provided with knurled knob arrangement for screwing on the body of the socket so that it can be securely fixed on the top.

7.4.3 The plug base and cover shall be firmly secured to each other and shall be sufficiently robust in construction to withstand normal usage.

7.4.4 The plug pins shall preferably be of single part. The earthing pin shall be slotted with a single slot and shall be larger in dimension than other pins.

7.4.5 The plug and socket contacts shall be self aligning type with best electrical continuity.

7.4.6 The plug shall be provided with dust proof cable entry suitable for receiving TRS flexible heavy duty copper conductor cable of specified size. The arrangement shall be such that the conductors are relieved from strain including twisting where they are connected to the terminals and that the outer surface of the cable at the place of entry is not damaged.

7.4.7 Insulating barriers forming an integral part of the plug shall ensure separation of metals and bare flexible conductors at different potentials.

7.5 Cable Termination

7.5.1 Switch socket shall have cable termination arrangement on the upper part of the housing and shall be provided with side entries, one on either side, through heavy duty double compression type rolled aluminium cable glands suitable for 1.1 KV grade PVC insulated armoured and PVC sheathed cables of size.

7.5.2 The terminal blocks shall be pressure clamp type for switch socket rated up to 63A and bolted lug type for higher ratings. The terminals shall be rated for at least 1.5 times the switch rating.

8.0 PAINTING

8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti-rust paint followed by two coats of anti-corrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.
8.4 The finishing shade shall be light grey shade no.631 as per IS: 5, unless specified otherwise.

9.0 TESTS AND INSPECTION

9.1 The switch sockets and plugs shall be subjected to routine tests as per IS-4160 and other relevant standards.

9.2 Wherever specified, additional tests shall be carried out on one switch socket and plug of each rating.

9.3 The tests shall be carried out in the manufacturer’s works in the presence of purchaser’s representative. In addition to the above tests, the equipment shall be subject to stage inspection at works and inspection at site for final acceptance.

9.4 These inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following descriptions written boldly.
- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

11.0 PACKING

11.1 The switch socket and plug shall be properly packed to safeguard against weather conditions and handling during transit. It shall be wrapped in polythene bags and an additional wrapping of bitumen paper shall also be provided to make it completely water proof before the equipment is packed in wooden crates.

11.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

12.0 SPARES

12.1 Spares for operation and maintenance
Item wise unit prices of spare parts shall be quoted.

12.2 Commissioning Spares
Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

12.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

12.4 All spare parts shall be identical to the parts used in the equipment.
13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
# ANNEXURE – I

## DOCUMENTATION FOR INTERLOCKING SWITCH SOCKET AND PLUG

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Description</th>
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<th>For Approval</th>
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<td>1.</td>
<td>Specification Sheet</td>
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<td>Y</td>
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<tr>
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<td>General arrangement and foundation drawing</td>
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</tr>
<tr>
<td>4.</td>
<td>Schematic / wiring diagram</td>
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<td>Y</td>
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<tr>
<td>5.</td>
<td>Illustrative and descriptive literature</td>
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<td>N</td>
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<tr>
<td>6.</td>
<td>Catalogue for bought out accessories</td>
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<td>7.</td>
<td>Installation operation and maintenance manual</td>
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<td>8.</td>
<td>Test Certificates</td>
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<tr>
<td></td>
<td>a) Type</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>b) Routine</td>
<td>N</td>
<td>N</td>
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<td>9.</td>
<td>Guarantee Certificate</td>
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<tr>
<td>10.</td>
<td>Certificate of flameproofness from statutory testing authority wherever applicable.</td>
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<td>11.</td>
<td>Spare parts list with identification marks</td>
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### Note:

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
TECHNICAL SPECIFICATION

BATTERY CHARGER
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1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well packed condition of Battery Charger Units.

1.2 The standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this specification shall comply with the latest issue of IS: 8623 Specification for low voltage switchgear and control gear assemblies and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment shall also comply with provisions of the latest issue of the Indian electricity Rules and other relevant Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy - Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy - Electrical.

4.0 DESIGN AND OPERATIONAL REQUIREMENTS

4.1 The Battery Charger Unit and its components shall be suitable for operating at the specified rating continuously with the specified voltage and frequency variations under the ambient conditions without exceeding the temperature rise limits specified in relevant standards and without any detrimental effect on any part.

4.2 The battery charger board shall consist of two units as follows:

(a) Float cum load cum Boost Charger

To supply continuous load and keep the battery in state in float mode. In Boost mode, for Initial charging of Battery and after power restoration subsequent to failure, to recharge the battery while simultaneously supplying load current.

(b) A stand by unit for (a) above.

4.3 The rated voltage of the float charger for lead acid battery shall be 2.2 Volt/ Cell and final charging voltage of the boost charger shall be 2.75 Volt/ Cell. The rated voltage of the float charger for Ni-Cd shall be minimum 1.4 Volt/ Cell and final charging voltage of the boost charger shall be minimum 1.7 Volt/ Cell. The rated output voltage of the charger under 4.2 (a) above shall be adjustable by ± 5% of the rated value manually.
4.4 Charging unit stated under 4.2 (a) above shall be fully automatic using silicon controlled rectifiers (SCR) common for Float and Boost service. Charger D.C. output voltage shall be maintained within ± 2% irrespective of the input supply variations and load variation of 0 to 100% by closed loop voltage feed back control system. The charger shall be provided with current limit feature.

4.5 The output voltage of the float charger shall be monitored and in case voltage falls below 90% of the rated voltage the stand by charger shall be automatically switched ‘ON’ with audio-visual alarm and annunciation. Time delay features shall be incorporated to avoid spurious changeover.

4.6 Boost charging shall be achieved through the same silicon controlled rectifier (SCR) which shall regulate the charger output automatically by current control closed loop system. Provision for manual adjustment of charger output shall also be made. Charger shall maintain its output current constant at starting rate/ finishing rate of battery charging current irrespective of variation in input supply and battery condition.

4.7 Transfer from float charging to boost charging and vice versa shall be automatic as per the battery charge condition.

4.8 During boost charging operation, arrangement shall be made so that DC power to load is not interrupted even if AC power fails during this operation. During Boost charge period, battery backup to load shall be arranged by a tapping from suitable point of the battery.

4.9 Suitable dropper diodes shall be provided to reduce the voltage across the load to 105% of the rated voltage at rated load current. When power supply to the charger fails, the dropper diodes shall be by-passed automatically through contactor so that full battery output voltage is available to the load.

4.10 Provision of suitable filters shall be made so that the ripple in output voltage shall not exceed 3% and 10% for float and boost charger respectively.

4.11 It shall be ensured that during boost charging, no over/under charging of cells takes place.

4.12 All the automatic features specified above shall also have provision of manual arrangement for control of charging rates and transfer from one charger to others.

4.13 Charger unit shall be provided with all required indication, metering, protection, control and alarm annunciation devices for safe and reliable operation and shall include at least as indicated in Annexure-I.

5.0 CONSTRUCTIONAL FEATURES

5.1 Each of the charger units shall be housed in separate metal clad cubicles of identical size suitable for floor mounting and arranged to form a compact switchboard.

5.2 The complete assembly shall be dust, damp and vermin proof type equivalent to IP-43 as per IS/IEC:60947. In case it is necessary to provide openings for ventilation, these shall be closed from inside by fine wire mesh. Forced ventilated panel shall not be acceptable.

5.3 The frame work of cubicles shall be of bolted/welded construction, fabricated out of cold rolled sheet steel of not less than 2 mm thickness. The thickness of base channel shall not be less than 3 mm, suitable reinforcement, wherever necessary, shall be provided.
5.4 Hinged doors shall be provided on both the front and back side for easy access. The door hinges shall be concealed type.

5.5 The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets. Gaskets without any discontinuity shall be preferred. Gaskets shall be held in position in groove in shaped steel work or these shall be 'U' type. Only one joint per gasket shall be permitted. Adhesive cement, if used, shall be of good quality so that the gaskets do not come off during service.

5.6 The mounting of the components shall be such that these are accessible for checking and replacement without the necessity of removing the adjacent ones, at the same time ensuring necessary degree of safety.

5.7 It shall be possible to carry out maintenance of one charger when the other is in operation.

5.8 The meters, switches and lamps shall be flush mounted type. All components of one unit shall be mounted on the same unit.

5.9 All the live parts shall be insulated. Parts which can not be insulated shall be provided with insulating barriers. These barriers shall provide shielding of all live parts to prevent accidental contact when the door is open. However, for the parts requiring handling normally, such as fuses/lamps etc., separate barriers shall be provided. The barriers in all cases shall cover the cable lug portions and shall be firmly secured, stable and durable. It shall, however, be possible to remove such barriers, if required.

5.10 At the equipment termination points, insulated phase barriers, PVC bolt caps, PVC hoses or insulating ribs shall be provided.

5.11 The outgoing terminal blocks shall be shrouded type or provided with insulating barriers.

5.12 Adequate arrangement for earthing shall be provided to safeguard the Operator or other personnel from electric hazards under all conditions of operation.

5.13 **Clearances and Creepage**

The clearances and creepage distances shall not be lower than the values specified below:

- i) Minimum clearance between two live parts : 20 mm
- ii) Minimum clearance between a live part & earth : 20 mm
- iii) Minimum creepage distance : 28 mm

5.14 **Insulation**

5.14.1 The insulation used shall be non-hygroscopic and may be of porcelain, epoxy resin or glass fibre moulded with plastic. It shall be of adequate electrical and mechanical strength to give trouble free service during normal operation and short circuit conditions.

5.14.2 The insulation shall be treated suitably to withstand the tropical conditions and atmospheric pollution as specified.

5.15 **Wiring**

5.15.1 The switch board shall be completely factory wired and ready for external connections.
5.15.2 The wiring shall be complete in all respect so as to ensure proper functioning of control, protection, interlocking and measurement.

5.15.3 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables of 1100 V grade of minimum 1.5 Sq.mm size.

5.15.4 All wiring shall be marked with dependent both ends marking as per IS: 5578. Numbered ferrules, reading from the terminals outwards, shall be provided at both ends for easy identification. These shall be interlocking type plastic ferrules.

5.15.5 The control cables shall be neatly arranged and properly supported on PVC wiring channel.

5.16 **Cable Termination**

5.16.1 The boards shall be designed for bottom entry of the power and control cables. Sufficient space shall be provided for ease of connection and termination of cable.

5.16.2 Provision for receiving one 415 V, 3 phase 4 wire incoming supply lines, one for each charger shall be made. However, DC output for battery and load shall be looped inside the panel and only one outgoing supply each for battery and load shall be provided.

5.16.3 The termination of cables shall be done through cable glands which shall be suitable for the cables.

5.16.4 Heavy duty double compression type rolled Aluminium cable glands shall be provided. The cable glands shall be mounted on a removable gland plate, provided at a minimum height of 75 mm from the bottom of the switchboard. Two spare knockouts of size 20 mm shall also be provided on the gland plate for future addition of control cables.

5.16.5 For all power cables, crimped type cable lugs of same material as of conductor shall be provided.

5.16.6 The internal power wiring shall be terminated in the terminal blocks for connection to the outgoing cables. These terminal blocks shall be pressure clamp type up to 35 Sq.mm, cable and bolted lug type for higher sizes of cables. These shall be protected type and rated for 1100 V service. The minimum current rating of terminal block shall be 16 Amp. The construction shall be such that after the connection of cables by means of lugs, necessary clearances and creepage distances are available.

5.16.7 Not more than two wires shall be connected to any terminal. If necessary a number of terminals shall be jumpered together to provide wiring points.

5.16.8 Wherever necessary, suitable clamps to support the vertical run of cables shall be provided.

5.16.9 The terminal blocks shall be grouped according to circuit functions and suitably numbered. 20% extra terminals shall be provided in the terminal block.

5.16.10 For power connection, suitable marking on the terminals shall be provided to identify the phases.

5.17 **Earth Bus**

5.17.1 A continuous earth bus of Aluminium of suitable size minimum 32 x 6 mm shall be run all over the length in the lower part of the board with two ends connected to the external earth terminals of the board.

6.0 **COMPONENT DETAILS**

6.1 **Rectifier Transformer**
This shall be double wound, air cooled, 3 phase type. Class ‘F’ insulating materials shall be used, with temperature rise limited to Class ‘B’. The windings shall be vacuum impregnated.

6.2 Thyristors and Diodes

The thyristors and diodes shall be properly selected to have adequate safety margin. A factor of safety of minimum 4 shall be taken for voltage surges and 2 for current ratings. The thyristors and diodes shall be mounted on their respective heat sinks which shall preferably be made of extruded Aluminium properly machined and providing intimate contact with the stud for heat dissipation. Each thyristor/diode shall be protected with properly designed snubber circuit.

6.3 Air Break Switches

The switches shall be heavy duty quick make, quick break type conforming to IS/IEC 60947. Switches shall be snap action rotary type. ‘ON’-‘OFF’ position of the switch shall be boldly indicated. The handle of switches shall remain fastened to the door even when the door is opened after turning the switch ‘OFF’. The AC input switch shall not be directly mounted on the door.

6.4 Fuses

For protection of thyristors/diodes, semi-conductor fuses shall be provided. All other fuses shall be HRC cartridge link type. They shall be suitable for the load and service required.

6.5 Contactors

The contactor shall be air break type of category AC-3/ DC-1 as per IS/IEC 60947. DC contactor shall be provided with arc chutes and magnetic blow out coil. The contactors shall not drop out even when the coil voltage drops to 65% of rated voltage.

6.6 Thermal Overload Relays

Adjustable bimetal thermal overload relays shall be provided. The bimetal relays shall be ambient temperature compensated. The thermal relays shall be provided with a manual resetting device on the door.

6.7 All ammeters and voltmeters shall be class 1.5 as per IS 1248 and shall be flush mounted type of minimum size 96 x 96 mm. Ammeters and Voltmeters for A.C. service shall be of moving iron type and that for D.C. service shall be moving iron or moving coil type. Zero adjuster shall be provided for operation from the front of the cases.

6.8 Printed Circuit Boards (PCBs)

The PCBs shall conform to IS 7405. These shall be of fibre or epoxy glass moulded of minimum thickness 1.5 mm and shall have gold plated contacts and silver or nickel plated tracks. All PCBs shall be of plug-in type contained in a dust proof box. PCBs shall be self diagnostic type and shall be provided with status indication. Metering points shall be provided on each PCB and the PCBs shall be clamped in position so that vibration or long usage does not result in loose contacts.

6.9 Timers
The timers shall be electronic, pneumatic or synchronous type conforming to IS: 5834 with manual/auto reset features as per the functional requirements. The repeat accuracy shall be within 5%.

6.10 Control and Selector Switches

6.10.1 All the control and selector switches shall be of rotary type with thermal utilization category of AC 11 or DC 11 as per IS/IEC:60947.

6.10.2 The control switches shall be spring return type and provided with pistol grip type handles.

6.10.3 The selector switches shall be stay-put type and provided with oval handle.

6.11 Signal Lamps

6.11.1 Signal lamps shall be provided to indicate the various circuit conditions and these shall be placed at a suitable height. The colour of the lamps for various functions shall be as follows:

Red -- Circuit ‘ON’
Green -- Circuit ‘OFF’
Amber -- Alarm and auto trip.

6.11.2 The lamps shall be LED type having lumen output of 200 millicandella in axial direction.

6.12 Audio Visual Alarm Annunciation

6.12.1 A solid state audio-visual alarm annunciation system shall be provided for the board. Audible annunciation shall be provided by means of hooter with provision of remote alarm and acknowledgment. Visual annunciation shall be provided by flashing of the respective facia window. The facia window shall have translucent glass or plastic cover with inscription in black letters. Each facia window shall be provided with two lamps connected in parallel. The cover plate of the facia window shall be flush with the panel and shall be capable of easy removal to facilitate replacement of lamps.

6.12.2 The following operating sequence shall be adopted for audio visual alarm and indication:

<table>
<thead>
<tr>
<th>System Condition</th>
<th>Visual Signal</th>
<th>Audible Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>Abnormal</td>
<td>Flashing</td>
<td>ON</td>
</tr>
<tr>
<td>Acknowledge</td>
<td>Steady ON</td>
<td>OFF</td>
</tr>
<tr>
<td>Return to normal</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>Test</td>
<td>Steady ON</td>
<td>ON</td>
</tr>
</tbody>
</table>

7.0 ACCESSORIES

7.1 The supply shall include the following accessories:

7.1.1 Space Heater

Each cubicle of the board shall be provided with a thermostatically controlled space heater, rated for 240 V, 50 Hz and controlled through double pole miniature circuit breaker. The space heater supply shall be tapped from incomer power supply.

7.1.2 Name Plates
7.1.2.1 The board shall have a large name plate on the top to indicate its name and designation.
7.1.2.2 Each cubicle shall be provided with a name plate.
7.1.2.3 All control switches, push buttons, lamps etc. shall have function identification labels.
7.1.2.4 Name plate shall be of black perspex with white engraving of minimum 3 mm thickness.
7.1.3 Fuse Puller
7.2 Any other accessories required but not specified shall also be supplied to make the board complete in all respects and ensure its safe and proper operation.

8.0 PAINTING
8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti-rust paint followed by two coats of anti-corrosive paint.
8.2 Epoxy based paint shall be used.
8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.
8.4 Unless otherwise specified the finishing shade shall be light grey having Shade No. 631 as per IS 5.

9.0 TESTS AND INSPECTION
9.1 The board shall be subjected to routine tests as per IS 8623 and other relevant standards. Heat run test, if required, shall be carried out.
9.2 Additional tests, wherever specified shall be carried out on one board of each rating.
9.3 All the above tests shall be carried out in presence of purchaser’s representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.
9.4 These inspections shall however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS
10.1 Drawings and documents as per Annexure-II shall be supplied unless otherwise specified.
10.2 All drawings and documents shall have the following description written boldly:
   - Name of client
   - Name of consultant
   - Enquiry / Order Number with plant / project name
   - Code No. and Description

11.0 SPARES
11.1 Spares for operation and maintenance
Item wise unit prices of spare parts shall be quoted.

11.2 Commissioning Spares
Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipments.

12.0 PACKING

12.1 The board shall be properly packed before despatch to avoid damage during transport, storage and handling.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual along with one set of drawings.

12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
## ANNEXURE - I

**REQUIREMENT OF PROTECTIONS, METERING, CONTROL AND INDICATIONS / ANNUNCIATIONS FOR BATTERY CHARGER**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>To be mounted on</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Float cum Load Charger</td>
</tr>
<tr>
<td>1</td>
<td><strong>A.C. Input Side</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>i) ON/OFF Switch</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>ii) HRC Fuses</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>iii) Contactor</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>iv) Thermal O/L Relay</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>v) Single phasing and Phase Reversal</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>vi) Voltmeter with SS</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>vii) Ammeter with SS</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>viii) Signal Lamp (ON/OFF)</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td><strong>Rectifiers</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Semiconductor fuses</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>ii) Filters with fuses</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>iii) Surge Suppressors</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td><strong>DC Output Side</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) ON/OFF Switch</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>ii) HRC Fuses</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>iii) Blocking Diodes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>iv) Voltmeter</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>v) Ammeter</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>vi) Signal Lamp (ON/OFF)</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>vii) Charging Ammeter (on demand type)</td>
<td>Yes</td>
</tr>
</tbody>
</table>
### TECHNICAL SPECIFICATION - BATTERY CHARGER

**PC150/E/4003/SecVI-5.4**

#### To be mounted on

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Float cum Load Charger</th>
<th>Standby Float cum Load Charger</th>
<th>Boost Charger</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Common Items</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Droper Diodes</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii) Solid State facia annunciator for:</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>-- Automatic changeover from one charger to another</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-- Rectifier fuse failure in float/standby float/boost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-- Incoming supply failure float/standby float/boost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-- DC output under voltage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-- Earth fault</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-- Single phasing and phase reversal</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>-- Filter fuse failure float/standby float/boost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii) Battery isolating switch and HRC fuses</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iv) Battery under voltage relay</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>v) Battery earth fault relay</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>vi) DC Contactor</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** Any other components as required for satisfactory operation of the battery charger shall be provided.
## ANNEXURE - II

**DOCUMENTATION FOR BATTERY CHARGER**

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Description</th>
<th>Documents Required (Y / N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>With Bid</td>
</tr>
<tr>
<td>1.</td>
<td>Specification Sheet</td>
<td>N</td>
</tr>
<tr>
<td>2.</td>
<td>Technical Particulars</td>
<td>N</td>
</tr>
<tr>
<td>3.</td>
<td>General arrangement drawings showing overall dimensions of the charger board and mounting details of various equipment inside the charger panel</td>
<td>N</td>
</tr>
<tr>
<td>4.</td>
<td>Foundation plan indicating certified dimensions, floor openings, weight, clearance etc.</td>
<td>N</td>
</tr>
<tr>
<td>5.</td>
<td>Schematic and Wiring Diagrams</td>
<td>N</td>
</tr>
<tr>
<td>6.</td>
<td>Descriptive literature of the charger and various components mounted in the panel.</td>
<td>N</td>
</tr>
<tr>
<td>7.</td>
<td>Characteristics curves for the charger and all other static and control devices, relays etc.</td>
<td>N</td>
</tr>
<tr>
<td>8.</td>
<td>Installation, Operation and Maintenance manual</td>
<td>N</td>
</tr>
<tr>
<td>9.</td>
<td>Guarantee Certificates</td>
<td>N</td>
</tr>
<tr>
<td>10.</td>
<td>Test Certificates</td>
<td>N</td>
</tr>
<tr>
<td>11.</td>
<td>Spare parts list with identification marks</td>
<td>N</td>
</tr>
</tbody>
</table>

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
TECHNICAL SPECIFICATION

BATTERY
## CONTENTS

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<th>DESCRIPTION</th>
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<td>3.0</td>
<td>SERVICE CONDITIONS</td>
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<td>4.0</td>
<td>OPERATING REQUIREMENTS</td>
</tr>
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<td>5.0</td>
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<td>8.0</td>
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<td>SPARES</td>
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<td>10.0</td>
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<td>11.0</td>
<td>DEVIATIONS</td>
</tr>
<tr>
<td>ANNEXURE - I</td>
<td>DOCUMENTATION FOR BATTERY</td>
</tr>
</tbody>
</table>
1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and despatch in well packed condition of batteries and accessories.

1.2 This standard shall be read in conjunction with the relevant part of Design Philosophy - Electrical.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the battery shall conform to the latest issue of the following standards:

- IS: 1651 -- Stationary cells & batteries, lead-acid type (with tubular positive plate)
- IS: 1652 -- Stationary cells & batteries, lead-acid type with plante positive plates.
- IS: 10918 -- Vented type nickel cadmium batteries

All accessories shall also conform to the relevant Indian Standard. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment offered shall comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy - Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy - Electrical.

4.0 OPERATING REQUIREMENTS

The battery shall be able to deliver rated ampere hours when discharged at the 10 hours rate of discharge to a final voltage of 1.85 V per cell for Lead Acid and at the 5 hours rate of discharge to a final voltage of 1.1 V per cell for Ni-Cd battery under the ambient conditions indicated in Design Philosophy - Electrical.

5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

5.1 The battery shall be of lead acid plante type and rated for 220V. Each battery bank shall consist of 110 number of cells.

5.2 Each cell shall be contained in a closed top container preferably transparent and unbreakable and shall incorporate positive plates, negative plates and separators of adequate dimensions. Lead acid battery shall be of plante plate type (positive plate).
5.3 The battery bank shall be complete with all necessary components such as lids, plugs, separators and buffers, inter-cell connectors, lead coated bolts and nuts, cell insulators etc.

5.4 The required quantity of electrolyte plus 10% extra quantity shall be supplied in suitable non-returnable containers along with the battery.

6.0 ACCESSORIES

The following accessories shall be supplied with each battery bank:

(a) 1 Set -- Battery Stand constructed out of teak wood without the use of any metal fastenings and coated with 3 coats of anti-acid paint. The stand shall be properly designed so that each cell shall be easily accessible for inspection, topping up etc. However, for Ni-Cd battery mild steel stand with alkali resistant paint may also be accepted.

(b) 1 Set -- Inter-row, inter-tier and inter-stand connectors and takeoffs. These shall be sized suitably to have adequate current carrying capacity and mechanical strength.

(c) 1 Set -- Cell Insulators

(d) 1 Set -- Stand Insulators

(e) 1 No. -- Centre zero cell testing voltmeter scaled 3-0-3 volts

(f) 2 Nos. -- Syringe type Hydrometers for measuring the specific gravity of the electrolyte

(g) 2 Nos. -- Gravity correction thermometers, mercury-in-glass type

(h) 1 Set -- Connecting bolt wrenches

(i) 1 No. -- Rubber syringe for tapping cells

(j) 1 No. -- Wall mounting type teak wood holder for Hydrometer and Thermometer.

(k) 1 No. -- Acid/Alkali resisting funnel.

(l) 1 No. -- Acid/Alkali resisting jug.

(m) 1 Pair -- Rubber gloves.

(n) 1 No. -- Rubber Apron.

All other accessories, not specified above, but required for satisfactory operation and maintenance shall also be supplied.

7.0 TESTS AND INSPECTION

7.1 Type tests shall be carried out as per relevant standards on two cells in the presence of Purchaser’s representative.

7.2 Acceptance tests shall be carried out as per relevant standards on each cell after installation at site.

7.3 In addition, the battery shall be subjected to stage inspection at works and inspection at site for final acceptance.
7.4 These inspections shall, however, not absolve the vendor from his responsibilities for making good any defect which may be noticed subsequently.

8.0 DRAWINGS AND DOCUMENTS

8.1 Drawings and documents as per Annexure-I shall be furnished by the Vendor unless otherwise specified.

8.2 All drawings and documents shall have following description written boldly:
- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

9.0 SPARES

Item wise unit prices of spare parts shall be quoted.

9.1 Any other spare parts required, but not specified, shall also be quoted.

10.0 PACKING

The battery cells and accessories shall be properly packed to safeguard against weather conditions and rough handling. It shall be wrapped in polythene bags with an additional wrapping bitumen paper to make it completely water proof before it is packed in crates. The packing box shall contain a copy of the installation operation and maintenance manual.

11.0 DEVIATIONS

11.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
### ANNEXURE – I

#### DOCUMENTATION FOR BATTERY

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<tr>
<td>3.</td>
<td>Dimensional drawings showing the cell arrangement on stand (Plan, front and side elevation) for each type of battery.</td>
<td>N</td>
</tr>
<tr>
<td>4.</td>
<td>Illustrative and descriptive literature giving the complete details of construction of battery</td>
<td>N</td>
</tr>
<tr>
<td>5.</td>
<td>Operation and maintenance instructions</td>
<td>N</td>
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<tr>
<td>6.</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>-- Type</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>-- Acceptance</td>
<td>N</td>
</tr>
<tr>
<td>7.</td>
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<tr>
<td>8.</td>
<td>Spare Parts lists</td>
<td>N</td>
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</tbody>
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**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
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</table>
1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and dispatch in well packed condition of power and control cables.

1.2 The standard shall be read in conjunction with relevant part of Design Philosophy - Electrical and other relevant references as specified therein.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of cables covered by this standard shall comply with the latest issue of following Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

- IS: 1554 Part (I) -- PVC insulated (heavy duty) electric cables for working voltages upto and including 1100 volts.
- IS: 1554 Part (II) -- PVC insulated (heavy duty) electric cables for working voltages from 3.3 KV upto and including 11 KV.
- IS: 7098 Part (I) -- Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100 volts.
- IS: 7098 Part (II) -- Cross linked polyethylene insulated PVC sheathed cables for working voltages from 3.3 KV upto and including 33 KV
- IS: 694 -- PVC insulated cables for working voltages upto and including 1100 volts
- IS: 5831 -- PVC insulation and sheath of electric cables

2.2 The design and operational features of the cables offered shall also comply with the provisions of latest issue of the Indian Electricity Rules and other relevant Statutory Rules & Regulations. The supplier shall, whenever necessary, make suitable modification in the cables to comply with the above mentioned rules.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated elsewhere in Design Philosophy - Electrical.

3.2 System Details

These shall be as indicated elsewhere in Design Philosophy - Electrical.

4.0 OPERATING REQUIREMENTS

The cables shall be suitable for operating continuously at the rated capacity as specified in relevant I.S. under the ambient conditions without exceeding the permissible temperature rise and without any detrimental effect on any part.
5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

5.1 The design, manufacture and workmanship of cables shall be in accordance with the latest practice.

5.2 All materials to be used shall be new, unused and of the best quality.

5.3 Conductors

The power cables shall be of stranded Aluminium / copper round or shaped conductors and control cables shall be of annealed high conductivity stranded copper round conductors. The conductors shall comply with the requirements of IS: 8130.

5.4 Insulation

The conductor insulation shall be XLPE and shall comply with relevant IS.

5.5 Fillers

The cables shall have suitable fillers wherever required, laid up with conductors to provide substantially circular cross section before the inner sheath is applied.

5.6 Inner Sheath

Inner sheath, wherever applicable shall be ST1/ ST2 type compound applied by extrusion process except for paper cables for which it shall be of lead or lead alloy.

5.7 Armouring

All power and control cables shall be armoured. The single core cables shall be armoured with hard drawn Aluminium taps/ wires or any other suitable nonmagnetic material. All other cables shall have galvanized steel wire / strip armouring.

5.8 Outer Sheath

The outer sheath shall be ST1/ ST2 type compound applied by extrusion process and suitable to withstand atmospheric pollution, resistance to termites, fire retardant and coloured black.

5.9 Screening

Screening over conductor and insulation shall be provided as per relevant standard unless specified otherwise. The screening for control cables if specified shall be of aluminium, mylor or equivalent and provided with tinned drain wire which shall be continuous and permanently connected to the screen.

5.10 Identification

The individual cores of cables shall be coloured as per relevant IS. Where it is not possible to distinguish the cores by colour, coloured strip shall be applied on the cores or core nos. shall be marked on each core at regular intervals. All cables shall carry the manufacturer’s name or trade mark, the cable size, voltage rating and year of manufacture at intervals not exceeding 100 meters. Running meter markings shall also be provided throughout the length of the cable.

5.11 Dimension
The overall dia. and dia. under armour of the cables shall be indicated by the vendor in the technical particulars. These shall be guaranteed with a tolerance of ± 5% but not exceeding 2 mm.

5.12 The cut ends of the cables shall be sealed by means of non-hygroscopic materials.

6.0 SPECIAL PURPOSE CABLES

6.1 Flame Retardant Low Smoke Cables

Flame retardant low smoke cables shall have outer sheath of PVC having following values.

- Minimum oxygen index - 29%
- Minimum temperature index - 250°C
- Maximum acid gas generation - 20%
- Maximum smoke density rating - 60%

6.2 Heat Resistant Cables

Heat resistant cables shall be of silicon rubber insulated laid circular with asbestos worming and overall glass fibre braided and varnished. Silicon rubber insulating compound shall conform to IS: 6380 and the constructional features shall conform generally to IS: 9968.

7.0 CABLE DRUM

7.1 The cables shall be supplied in non-returnable wooden drums (or steel drums if specified) of heavy construction. The wood used for construction of the drums shall be properly seasoned, sound and free from defects.

7.2 Cables shall be supplied in specified drum lengths. Where no such indication is given, standard drum lengths may be offered.

7.3 The tolerance on each drum of cable shall not exceed ± 2.5%. However, no negative tolerance on HV cables is acceptable.

7.4 All cable drums shall have stencilled data as per relevant IS as well as the purchaser’s order no., item no. & drum no.

8.0 TESTS AND INSPECTION

8.1 The following tests shall be carried out on the cables as per relevant IS.

i) Routine Tests - On all cables
ii) Acceptance tests - On representative length of each size
iii) Type tests - Wherever specified on one cable drum of each size

8.2 In addition, the following tests shall be carried out on all fire retardant low smoke cables as per IS or as per the following standards:

i) Oxygen and temperature index test as per ASTM-D-2863
ii) Acid gas emission test as per IEC-754 Part-I
iii) Smoke density test as per ASTM-D-2843
iv) Flammability test as per IEC-332 Part-I or IS-10810

8.3 All the above mentioned tests shall be carried out in the presence of purchaser’s representative. In addition, the cables shall be subjected to stage inspection at works and inspection at site for final acceptance.

8.4 These tests and inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

9.0 DRAWINGS AND DOCUMENTS

9.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

9.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

10.0 DEVIATIONS

10.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
## ANNEXURE - I

### DOCUMENTATION FOR CABLES

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<tbody>
<tr>
<td>1.</td>
<td>Specification Sheet</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>2.</td>
<td>Technical Particulars</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>3.</td>
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<td>N</td>
<td>N</td>
<td>Y</td>
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<tr>
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<td>Installation, Termination and Jointing Instructions</td>
<td>N</td>
<td>N</td>
<td>Y</td>
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<td>5.</td>
<td>Test certificates</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>a)</td>
<td>Routine</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>b)</td>
<td>Type</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>6.</td>
<td>Guarantee Certificates</td>
<td>N</td>
<td>N</td>
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### Note:

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
TECHNICAL SPECIFICATION

PREFABRICATED LADDER TYPE CABLE RACKS
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<td></td>
<td>ANNEXURE - I DOCUMENTATION FOR PREFABRICATED LADDER TYPE CABLE RACKS</td>
</tr>
</tbody>
</table>
1.0 SCOPE

1.1 This standard covers the technical requirements of design, fabrication, testing at works and delivery in well-packed condition of prefabricated ladder type cable racks.

1.2 The standard shall be read in conjunction with Drawing Nos. PDS: E 530 to 538 (9 Sheets).

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the cable racks covered by this standard shall comply with the latest issue of following and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

- IS: 733 -- Wrought aluminium and aluminium alloy bars, rods and sections for general engineering purposes
- IS: 2629 -- Recommended practice for hot dip galvanising on iron and steel
- IS: 4759 -- Hot dip zinc coatings on structural steel and other allied products

2.2 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

3.1 Ladder type cable racks shall be fabricated as per attached Drawing Nos. PDS: E 530 to PDS: E 538 (9 Sheets).

3.2 Cable racks and accessories such as coupler plate, tees, bend, elbows etc. shall be fabricated from 3 mm thick mild steel galvanised sheet or 4 mm thick aluminium 19000 H2 alloy sheet extrusion conforming to designation No. 64430 and condition WP as per IS: 733.

3.3 G.I. racks and accessories shall have zinc coating of 800 gm/sq. metre applied by hot dip galvanising process. Galvanising shall be uniform, adherent, smooth and free from defects.

3.4 The finished rack and accessories shall be free from sharp edges and corners, burrs and un-evenness. Stepped arrangement of bending is not acceptable. The channel members in the bending shall have uniform curvature and shall be made out of single piece.

3.5 The racks shall be supplied in minimum length of 2.4 metre.

3.6 Each straight length and bend shall be supplied with two coupling plates fitted at each side channel at one end. The coupling plates shall be supplied with bolts, nuts and washers fitted at the other four holes for fixing to adjoining member.

3.7 Coupling plate shall be designed to permit longitudinal adjustment upto ± 10 mm and skew upto 10°.
3.8 Clamping arrangement as per attached drawings shall be provided for fixing the rack with the cross support as required.

3.9 All the bends, tees and junctions shall be made sufficiently rigid by providing suitable reinforcement on rungs as required.

3.10 The rungs shall be connected to the side channels by continuous welding alongwith three sides of rung. Aluminium rack shall be welded by TIG welding process.

3.11 All hard wares such as nuts, bolts, washers and crank bolts shall be cadmium plated.

3.12 Tolerances in various dimension shall be follows:

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<th>Dimension</th>
<th>Tolerance</th>
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<tbody>
<tr>
<td>Length</td>
<td>± 5 mm</td>
</tr>
<tr>
<td>Width</td>
<td>± 2 mm</td>
</tr>
<tr>
<td>Height</td>
<td>± 1 mm</td>
</tr>
<tr>
<td>Bend</td>
<td>± 1 mm</td>
</tr>
<tr>
<td>Thickness</td>
<td>± 0.2 mm</td>
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</tbody>
</table>

Positive tolerance on total quantity upto ± 5% is acceptable. However, negative tolerance on total quantity is not acceptable.

4.0 MARKING

The packing shall be clearly marked on the outside (on top side & ends) in indelible ink with the following minimum details:

- Part No.
- Size of Tray (Length x Width x Height)
- No. of Tray / Section, Total Weight
- Material Specification
- Client's Name
- Purchase Order No.
- Manufacturer’s Name

5.0 TESTS AND INSPECTION

5.1 Following tests shall be carried out on prefabricated cable racks:

Visual inspection and checking for

i) Quality and thickness of raw material

ii) Dimensions as per drawing.

iii) Quality of welding (before galvanising for G.I. racks)

iv) Preparation of metal surfaces (for G.I. racks).

5.2 After galvanising, G.I. cable racks shall be subjected to following tests as per IS:4759.

i) Mass of galvanising coating -- At any location the thickness of zinc coating shall not be less than 90 micron. However, average thickness of zinc coating shall not be less than 113 micron.
ii) Uniformity of galvanising coating.
iii) Adhesion of galvanising coating.
iv) 3 samples from each lot shall be taken for testing.
v) From each lot and size of rack, measure length of 10 trays and average length to be multiplied by number of trays to arrive for total length.

5.3 All the above tests shall be carried out in the manufacturer’s works in the presence of Purchaser’s representative. In addition to the above tests, the cable racks and its accessories shall be subjected to stage inspection at works and inspection at site for final acceptance.

5.4 These tests and the Purchaser’s inspection shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

6.0 DRAWINGS AND DOCUMENTS

6.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

6.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

7.0 DEVIATIONS

7.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
## ANNEXURE - I

### DOCUMENTATION FOR PRE-FABRICATED LADDER TYPE CABLE RACKS

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<td>N</td>
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<td>3.</td>
<td>General Arrangement Drawings, showing details of rack, coupling pieces, fasteners, etc.</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<td>Test certificates</td>
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<td>5.</td>
<td>Guarantee Certificates</td>
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Y - Yes, N - No
TECHNICAL SPECIFICATION
LOCAL CONTROL STATION
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ANNEXURE - I DOCUMENTATION FOR LOCAL CONTROL STATIONS
1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of Local Control Stations.

1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical and other relevant references as specified therein.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS/IEC:60947 and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of the Indian Electricity rules and other relevant statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modification in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated elsewhere in Design Philosophy - Electrical.

3.2 System Details

These shall be as indicated elsewhere in Design Philosophy - Electrical.

4.0 OPERATIONAL REQUIREMENTS

This equipment and associated components shall be suitable for operating satisfactorily under the specified ambient and system conditions.

5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

5.1 The Control Stations shall be suitable for control voltage not exceeding 500V, 50 Hz AC or 220V D.C.

5.2 The enclosure shall be of die cast Aluminium alloy LM-6. As an alternative to cast Aluminium, fibre glass enclosure is also acceptable.

5.3 The equipment shall have dust, hose and weather proof construction equivalent to IPW-55 as per IS/IEC:60947. These shall be suitable for outdoor location without any additional protection or cover.

5.4 A rain-hood shall be offered as an additional item. It shall be made of 14 gauge Aluminium sheet bent to shape. In case of fibre glass enclosure, these can be made of fibre glass.
5.5 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel cadmium plated or zinc passivated. For fibre glass enclosure Nylon PVC bolts of diameter 8 mm may be used.

5.6 The control station shall preferably be with bolted cover. The bolts for retaining the cover in position shall be provided with 10 mm dia. stainless steel and these shall be so arranged that they do not pierce into the door gasket.

5.7 All the components shall be mounted on a base plate inside the enclosure. Necessary actuating system for control switch, push button, non yellowing acrylic/ glass cover for ammeter and indication lamps shall be provided on the front cover. No wiring shall be carried out on the front cover.

5.8 The layout of components in the control station shall be liberal and standardised. All mating surfaces shall be smoothly machined and shall be of sufficient width of at least 6 mm. The covers shall be provided with continuous gasket made of neoprene or synthetic rubber to prevent ingress of dust and moisture. The gasket shall be held in position in groove provided in the enclosure and shall be pressed all around uniformly by suitably shaped projection of the door. Gaskets simply glued to the surface are not acceptable.

5.10 The enclosure shall be suitable for mounting on wall or on steel structure. 4 Nos. holes suitable for 12 mm bolts shall be provided outside the enclosure for fixing the control stations.

5.11 The internal wiring shall be carried by means of single core PVC insulated 1.5 sq. mm stranded copper conductor cable. All termination shall be made with crimping type proper size lugs and shall be properly ferruled.

5.12 The control stations shall be completely factory wired and ready for external cable connection.

5.13 For easy identification, numbering ferrules shall be provided on all wiring at both ends i.e. equipment end and terminal block end. Terminals for external wiring shall be numbered.

5.14 The enclosure shall be provided with two earthing terminals with studs of 8 mm. dia. projecting outside the enclosure for connection to earth. These terminals shall not pierce through the enclosure and shall be marked with earthing symbol.

5.15 Each control station shall be provided with minimum 2 mm thick stainless steel name plates or consisting of black Perspex with white engraving indicating the code number and description of the equipment controlled by it. Similar labels shall be provided for all indication lamps, push buttons and control switches. The name plate and label shall be fixed with screws only.

6.0 SPECIAL FEATURES FOR FLAME PROOF LOCAL CONTROL STATION

6.1 The enclosure shall be in addition, of flameproof execution as per IS: 2148.

6.2 The control stations shall be suitable for hazardous area of enclosure group and temperature class as indicated in Design Philosophy - Electrical.

6.3 Cables shall enter the terminal box through flame proof cable gland. From the terminal chamber to the main enclosure, the connections shall be made through proper
bushings. Direct entry of external cables into the main enclosure shall not be accepted. All entries shall be provided with stainless steel inserts.

6.4 An additional earthing terminal inside the terminal chamber shall be provided.

6.5 Local control stations and cable gland must be certified by the Central Mining Research Institute, Dhanbad or any other statutory authority for use in the specified hazardous area.

7.0 COMPONENT DETAILS

7.1 Trip-Neutral-Close Switch

TRIP-NEUTRAL-CLOSE switch shall be double pole, 3 position, pistol grip, rotary type having self spring return feature to neutral position. The contacts shall be of phosphor bronze and shall be provided with two breaks in series. Mechanical sequence device to prevent two successive movements to the same position shall be fitted. The switch shall be capable of being padlocked in the ‘TRIP’ position.

7.2 ‘Auto-Manual’ Switch

‘Auto-Manual’ switch shall be single pole stay put type having three positions “AUTO-OFF-MANUAL”. Provision shall be made to padlock the switch in the “OFF” position.

7.3 Selector Switch / Lock Service Switch

These shall be single pole stay put type having two position with a pistol grip handle and capable of being padlocked in one of the position.

7.4 All the switches shall be rotary type with snap or wiping action contact and having a set of normally open and closed contacts in each position. All switches shall be provided with pistol grip handle.

7.5 ‘Off-Auto-On’ Switch

7.5.1 ‘OFF-AUTO-ON’ switch shall be in minimum three stack configuration, each stack having three positions with spring return from ‘ON’ to ‘Auto’ position and lockable in ‘OFF’ position by means of padlock.

7.5.2 The switch shall have sliding contact between ‘AUTO’ and ‘ON’ position. In ‘OFF’ position the contact shall be completely broken from ‘AUTO’ position.

7.6 Push Buttons

These shall be spring loaded, with a set of normally closed and open contacts. The push buttons for ‘start’ shall be shrouded type and coloured green while ‘stop’ push buttons shall be un-shrouded type and coloured red. Provision shall be made to padlock the ‘stop’ push button in ‘OFF’ position. The fixing ring shall be metallic white. An oil proof rubber cap shall preferably be provided.

7.7 The switches and push buttons shall conform to utilization category AC11/ DC11 as per IS/IEC:60947. The contact shall be rated to make, break and carry inductive current of 5 Amp. at 415 V AC and 1 Amp of 220V DC. The contact arrangement shall be as shown in the terminal drawings. Built in locks instead of padlocking are not acceptable.
7.8 Indication Lamps

7.8.1 LED type indication lamps shall be provided to indicate the various circuit conditions as shown in the terminal drawings.

7.8.2 The LEDs shall provide good illumination through a viewing angle of 180º. The LEDs shall have lumen output of 200 milli Candella in the axial direction.

7.8.3 The colour of the LED indication for various functions shall be as follows:-
   RED : For ‘ON’ Indication
   GREEN : For ‘OFF’ Indication
   WHITE : For “Ready for Service” Indication

7.9 A.C. Ammeters

The ammeter shall be flush mounting, moving iron spring controlled type, of accuracy class 1.5 as per IS:1248, with square face of minimum size 72 mm x 72 mm having scale range 0-240º. The ammeter shall be provided with uniform scale up to CT primary current and compressed end scale up to 6 times the CT primary current. Adjustable red pointer shall be provided to indicate the full load current of the motors. Zero adjusters shall be provided for operation from the front of the meter. All ammeters shall be operated through 1Amp. CTs only.

7.10 D.C. Ammeters

The D.C. ammeter shall be shunt operated. These shall be moving coil or moving iron type of accuracy class 1.5 as per IS: 1248.

7.11 Terminal Blocks

All control stations shall be provided with terminal blocks. Terminal blocks shall be located at a minimum distance of 50 mm from the bottom of the enclosure. The terminal blocks for the control station shall be suitable for conductor sizes of 2.5 mm². These shall be of pressure clamp type design mounted on the base channel. The minimum rating of terminal block shall be 16 Amp.

7.12 Cable Glands

The cables for the external connections, shall enter the terminal chamber through heavy duty double compression type rolled Aluminium cable glands suitable for 2.5 sq. mm PVC insulated, armoured, and PVC sheathed copper conductor 1.1 KV grade cables. The number and cores of control cables shall be as per requirement. The cable gland shall be fitted in a threaded hole.

8.0 PAINTING

8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.
8.4 Unless otherwise specified, the finishing shade shall be of light grey having shade no. 631 as per IS: 5.

9.0 TESTS AND INSPECTION

9.1 All equipment shall be routine tested as per relevant standards.

9.2 Additional tests, wherever specified, shall be carried out.

9.3 All the above mentioned tests shall be carried out in the presence of purchaser’s representative. In addition, the equipment shall be subjected to stage inspection at works and inspection at site for final acceptance.

9.4 These inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of spare parts shall be quoted.

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipment.

12.0 PACKING

12.1 The local control stations shall be properly packed to safeguard against weather conditions and handling during transit. It shall be wrapped in polythene bags and an additional wrapping of bitumen paper shall also be provided to make it completely water proof before the equipment is packed in wooden crates.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.
13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
# ANNEXURE - I

## DOCUMENTATION FOR LOCAL CONTROL STATIONS

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<th>Documents Required (Y / N)</th>
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<tr>
<td>1.</td>
<td>Specification Sheet</td>
<td>N</td>
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<td>2.</td>
<td>Technical Particulars</td>
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<td>General Arrangement Drawings</td>
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<td>6.</td>
<td>Catalogues of bought out accessories</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>7.</td>
<td>Spare parts list</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>8.</td>
<td>Installation, Operation and Maintenance manual</td>
<td>N</td>
<td>N</td>
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<tr>
<td>9.</td>
<td>Test certificates</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>a) Routine</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>b) Type (only for flameproof equipment)</td>
<td>N</td>
<td>N</td>
</tr>
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<td></td>
<td>c) For enclosure</td>
<td>N</td>
<td>N</td>
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<td>10.</td>
<td>Guarantee Certificates</td>
<td>N</td>
<td>N</td>
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</table>

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
TECHNICAL SPECIFICATION
JUNCTION BOX
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</table>
1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing and inspection at works and delivery in well packed condition of junction boxes.

1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical and other relevant references as specified therein.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of relevant Indian standards unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 Flameproof & increased safety junction boxes shall in addition, comply with the requirement as laid down in IS: 2148 & IS: 6381 respectively.

2.3 The design and constructional features of the junction boxes offered shall also comply with the provision of latest issue of the Indian Electricity Rules and other relevant Statutory Rules & Regulations. The supplier shall, whenever necessary, make suitable modification in the equipment to comply with the above mentioned rules.

2.4 Wherever any requirement laid down in this standard differs from that in Indian Standard specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy - Electrical.

3.2 System Details

The details of power supply system shall be as indicated in Design Philosophy – Electrical.

4.0 GENERAL DESIGN & CONSTRUCTIONAL FEATURES

4.1 The junction boxes shall be dust and weather proof and suitable for installation outdoors without extra protection. The degree of protection shall be IP-55 as per IS/IEC:60529.

4.2 The junction boxes shall be of die cast aluminium alloy LM-6 with domed / suspension covers.

4.3 The casting of the junction boxes and their cover shall be pressure die cast. The casting shall be uniform and free from blow holes. All mechanical surfaces shall be free from burrs, dents and internal roughness.

4.4 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel cadmium plated or zinc passivated. For fibre glass enclosure Nylon PVC bolts of diameter 8 mm may be used.

4.5 The clearances and creepage distances shall be maintained inside the junction boxes as per relevant Indian standard.
4.6 The junction boxes shall be suitable for wall / structure / ceiling mounting and necessary arrangement for mounting the same shall be provided.

4.7 The junction boxes shall be provided with continuous gasket made of neoprene or synthetic rubber to prevent ingress of dust. The gasket shall be held in position in groove provided in the enclosure and shall be pressed all around uniformly by suitably shaped projection of the door. Gaskets simply glued to the surface are not acceptable.

4.8 The junction boxes housing terminal block shall be moulded type made of DMC / Fibre glass. Threaded terminals shall be made of brass (nickel plated or tinned) and provided with two tightening threaded nuts and four washers all made of brass (nickel plated or tinned). The terminals shall have two shorting links each horizontally placed connecting three terminals.

4.9 The terminal block shall be fitted with junction boxes base by means of 2 nos. 1/2" long nickel plated brass screws.

4.10 The junction boxes shall be provided with two nos. external earthing terminals and 1 no. internal earthing terminal.

4.11 All live parts inside the junction boxes shall be insulated and shall withstand a test voltage of 2.5 KV for 1 minute.

4.12 The junction boxes shall be provided with heavy duty double compression type rolled Al cable glands to suit the cable entries.

4.13 Threaded blanking plugs shall be provided for junction boxes to plug out the entries not in use as indicated in bill of quantities enclosed.

4.14 The junction boxes shall be provided with a blank stainless steel tag plate fastened to the junction box top cover with two stainless steel screws. The plate shall be at least 25 mm wide, 100 mm long and 1 mm thick.

4.15 For flameproof / increased safety junction boxes, the manufacturer shall submit copies of test certificates from statutory authorities clearly stating that the junction boxes as well as cable glands / blanking plugs are suitable for hazardous area.

4.16 **15 Amp. Junction Box**

4.16.1 The junction boxes shall be 4 way dome cover type.

4.16.2 The dimensions of the junction boxes with their cover and accessories shall be generally as per PDS: E-547.

4.16.3 The junction boxes housing terminal block shall be moulded type made of DMC / Fibre glass as per Drg. no. PDS: E-557.

4.17 **63 Amp. Junction Box**

4.17.1 The junction boxes shall be 3 / 4 way dome cover type.

4.17.2 The minimum internal diameter of the box shall be 240 mm.

5.0 **SPECIAL FEATURES FOR JUNCTION BOXES FOR HAZARDOUS AREA**

5.1 For increased safety junction boxes, the terminals shall be provided with positive locking device against loosening.
5.2 The enclosure shall be in addition, of increased safety execution, Exe, as per relevant standard and shall be suitable for installation in classified hazardous area.

5.3 The junction boxes shall be liberally dimensioned in order to avoid temperature rise inside the enclosure which may damage the insulating materials or gaskets employed therein.

5.4 Cables shall enter the terminal box through increased safety compression type cable glands. From the terminal chamber to the main enclosure, the connections shall be made through proper bushings.

5.5 An additional earthing terminal inside the terminal chamber shall be provided.

5.6 The junction boxes shall be provided with Brass-Nickel plated shorted links. The terminal block shall be made of non-hygroscopic compound. Bakelite / Hylam shall not acceptable.

5.7 All screws / bolts and nuts shall be of stainless steel.

5.8 Junction boxes and cable glands must be certified by Statutory Authorities for use in the specified hazardous area. Equipments certified by overseas authorities shall obtain certificate of compliance / letter of opinion from respective statutory authorities.

5.9 Duly wired prototype samples for junction boxes shall be submitted for scrutiny as and when called for.

5.10 Type Test certificates for increased safety type junction boxes and cable glands along with blanking plugs shall be supplied.

6.0 PAINTING

6.1 Epoxy based electrostatic powder coating paint shall be provided on exterior surface while the interior of junction boxes shall be painted with anti-condensate paint. The painting shall be able to withstand corrosive atmosphere.

6.2 Unless otherwise specified, the finishing shade shall be grey having shade no. 632 as per IS-5.

6.3 The terminal block of junction boxes shall be painted with Red, Yellow, Blue & Black colour for phase indication.

7.0 TESTS AND INSPECTION

7.1 The junction boxes shall be routine tested as per relevant standards.

7.2 Additional tests, wherever specified, shall be carried out on one unit of each rating.

7.3 The procedure & extent of the physical checks, routine & type test shall be governed by Quality Assurance Plan mutually agreed and approved by Inspection Authority.

7.4 All the above mentioned tests shall be carried out in the presence of purchaser’s representative. In addition, the equipment shall be subjected to stage inspection at works and inspection at site for final acceptance.

7.5 These inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.
8.0 PACKING

Each junction box and cable gland shall be suitably packed and protected from damage due to transportation, loading and unloading. Threaded fittings shall have plastic caps to protect the threading.

9.0 DRAWINGS AND DOCUMENTS

9.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

9.2 All drawings and documents shall have the following descriptions written boldly:
   - Name of client
   - Name of consultant
   - Enquiry / order number with plant / project name
   - Motor Code No. and Description

10.0 SPARES

10.1 Spares for operation and maintenance
Item wise unit prices of spare parts shall be quoted.

10.2 Commissioning Spares
Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

10.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

10.4 All spare parts shall be identical to the parts used in the equipment.

11.0 DEVIATIONS

11.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
### ANNEXURE - I

#### DOCUMENTATION FOR JUNCTION BOXES

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<tr>
<td>2.</td>
<td>Technical Particulars</td>
<td>N</td>
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<td>3.</td>
<td>Certified dimensional drawing, including mounting details</td>
<td>N</td>
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<tr>
<td>4.</td>
<td>Drawing showing constructional details</td>
<td>N</td>
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<td>5.</td>
<td>Illustrative and Descriptive catalogues</td>
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<tr>
<td>6.</td>
<td>Spare parts list</td>
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<tr>
<td>7.</td>
<td>FLP/Exe certificates for junction boxes and terminals conforming to IEC/ISS (CMRI, CCE, DGFASLI and BARC for terminals)</td>
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</tr>
<tr>
<td>8.</td>
<td>Certificate for weather proof construction for junction boxes as per IPW-55</td>
<td>N</td>
</tr>
</tbody>
</table>

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
TECHNICAL SPECIFICATION

ELECTRICALS FOR OVERHEAD CRANES & HOISTS
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</table>
1.0 **SCOPE**

1.1 This standard covers the technical requirements of design, engineering, manufacture, testing at works, supply at site, erection, site testing and commissioning of the complete electrical equipment and accessories as required for the overhead travelling crane and hoists.

1.2 This standard shall be read in conjunction with relevant mechanical specifications, other relevant standards / specifications.

1.3 The scope of work shall include but not limited to the following items:

   i) Drive motors
   ii) Starting resistors (in case of slip ring motors)
   iii) Power control panel
   iv) Control stations
   v) Limit switches
   vi) Electromagnetic brakes
   vii) Power and control cables with accessories
   viii) Earthing of all equipment
   ix) All other items, not specified but, required for safe and proper operation

1.4 The owner shall provide one no. medium voltage feeder for each crane / hoist and terminate the feeder cable in an isolator located at one end of the bay at a height of 1.5 m from the operating floor. The vendor shall indicate the exact power requirement (running and peak) to enable the owner to size and provide the power supply feeder.

1.5 Further distribution of power from this isolator onwards shall be in the vendor’s scope.

2.0 **STANDARDS TO BE FOLLOWED**

2.1 The design, manufacture, testing and installation of the equipment shall comply with the latest issue of IS-6547, IS-807 and other relevant Indian Standard specifications and codes of practices. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The equipment and installation shall also comply with the provisions of latest issue of Indian Electricity rules and other statutory acts and regulations.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification, the requirement specified here-in shall prevail.

3.0 **SERVICE CONDITIONS**

3.1 **Ambient Conditions**

   These shall be as indicated in Design Philosophy - Electrical.

3.2 **System Details**

   These shall be as indicated in Design Philosophy - Electrical.
3.3 The owner shall provide only three phase power at the specified medium voltage. For lighting, control and plug supply the vendor shall provide necessary single phase step-down transformers.

3.4 All the electrical equipment shall be so designed that enable the crane / hoist to operate at its rated capacity and specified duty cycle with the system variation under the ambient conditions without exceeding the permissible temperature rise and without any detrimental effect on any part.

4.0 GENERAL DESIGN AND CONSTRUCTIONAL REQUIREMENTS

4.1 The electrical system and installation shall be designed as per latest practice to provide maximum reliability, flexibility, safety to personnel and equipment and ease of operation and maintenance.

4.2 All equipment shall have adequate and standard ratings as per ISS.

4.3 All electrical equipment to be located in indoor plant area shall be enclosed in dust, damp and vermin proof enclosure equivalent to IP-54 as per IS/IEC:60529.

4.4 Equipment to be located outdoor shall be weather proof and have IPW-55 protection as per IS/IEC:60529 and shall also be provided with canopy as far as practicable.

4.5 The equipment to be located in hazardous area shall have additional protection as follows:

a) Zone – I All the equipment shall be in flameproof execution.

b) Zone – II The equipment producing sparks under normal operation shall be in flameproof execution and others shall be in increased safety execution.

The equipment shall be suitable for the enclosure group and temperature class as indicated in Design Philosophy - Electrical. The equipment selected shall conform to relevant Indian Standard Specification and must be certified by Central Mining Research Institute, Dhanbad or any other statutory authority for use in the specified hazardous area.

4.6 The pendant push button shall be light weight enclosure of aluminium/ polypropylene etc. In case of hazardous areas, the loop between the pendant push button and the crane control panel shall be made intrinsically safe by using suitable isolators. Alternatively certified flame proof components and increased safety terminals can be hosed in the hose proof aluminium / polypropylene enclosure.

4.7 Special care shall be taken to ensure that the parts to be opened for inspection and maintenance retain their dust tightness even after repeated opening and closing operations.

4.8 All mating surfaces shall be properly machined. Neoprene gaskets shall be used for dust and weather proofing. The gaskets shall be without any discontinuity.

4.9 Only non-hygroscopic materials shall be used for insulation. All insulation shall be specially impregnated to withstand ambient conditions and atmospheric pollution.

4.10 All live parts shall be adequately protected to prevent inadvertent or accidental contact.
4.11 The minimum clearance and creepage distance of M.V. equipment shall be 20 and 28 mm respectively and shall be positively maintained after connections.

4.12 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel cadmium plated or zinc passivated.

4.13 Earthing terminals complete with sockets and identification marks shall be provided on the enclosure of all electrical equipment. The number of terminals shall be two for equipment rated above 240V and one for those rated 240V and below. Additional internal earthing arrangement shall be provided for flameproof equipment.

4.14 All equipment shall be provided with stainless steel name plates containing the particulars as per relevant IS along with the description and code nos. of equipment.

4.15 All the electrical equipment shall be provided with separate terminal box, heavy duty double compression type rolled aluminium cable glands, proper crimping lugs and anti-vibration type terminals suitable for the cable sizes required.

4.16 Enclosure for limit switches, pendant push button, junction boxes and magnets etc. shall be of cast aluminium. Enclosure for control panel, transformer and resistors may be of sheet steel. The thickness of the sheet steel for the enclosure shall not be less than 2.5 mm. All enclosures shall be suitably painted to withstand atmospheric pollution as mentioned in the Design Philosophy - Electrical.

4.17 The doors or inspection covers shall be provided with threaded knobs or butterfly nuts made of plated carbon steel. Copper or copper alloys shall not be used outside the enclosures.

4.18 To facilitate maintenance and testing of all electrical equipment:
   a) Disconnecting links shall be provided where necessary.
   b) All cable lugs and terminals shall be numbered in a permanent form corresponding to the wiring diagram.
   c) Easy access and adequate working space shall be provided around all motors, panels, limit switches etc. safety railing shall be provided, where necessary.

5.0 EQUIPMENT SPECIFICATION

5.1 Power Connection

5.1.1 The main supply shall be obtained by flexible cable or otherwise as per requirement.

5.1.2 In case of overhead bare conductors, they shall be of copper and mounted on side of the crane bridge. Four number of gunmetal type current collector with renewable carbon inserts shall be used for power connection. One end of the bare conductor shall be connected to the owner's isolator by means of fixed cable.

5.1.3 In case of flexible cable arrangement, the cable shall be connected at one end of the crane and the other end to owner's isolator. The cable shall be hung at intervals by festooned type arrangement.

5.1.4 In either case the power fed to the trolley shall be by means of flexible cables fixed and supported by festooned arrangement.
5.1.5 The arrangement of fixing and supporting the flexible cables shall be such that the cable is not damaged due to repeated travelling of the crane and trolley. Supporting G.I. wire shall be provided, wherever required.

5.1.6 The collector rollers and shoes shall be designed to avoid sparking.

5.2 **Power Control Panel**

5.2.1 The panel shall house all the necessary electrical equipment for distribution of power and control of individual equipment/circuit.

5.2.2 The panel shall be totally enclosed, floor mounting, dead front, free standing type in cubicle construction.

5.2.3 The panel shall house the following:
   i) For incoming supply
      - Triple pole switch fuse units
      - Supply ‘ON’ signal lamps (LED Type)
   The above switch shall cut off all power driven and associated equipment on the crane except lighting and plug supply circuits.
   ii) For motors
      - Reversing type starter with necessary contactors and timers.
      - Other controlling relays and devices.
   iii) For lighting, control and plug supply
      - Single phase transformers
      - Isolating switch fuse units on primary and secondary sides.

5.2.4 All switches shall be motor duty type (AC 23) and rated for 1.5 times of the full load current of the circuit. The incoming switch shall be interlocked with the panel door.

5.2.5 All contactors shall be air break type and of AC4 utilization categories. The thermal rating of the contactor shall be 1.5 times the full load current of the circuit.

5.2.6 The power contactors shall be interlocked electrically and mechanically so that there shall be no possibility of simultaneous operation of two contactors for the same motor.

5.2.7 Electrical interlock shall be provided between main hoist and micro hoist motors.

5.2.8 All thermal overload relays shall have in-built single phasing feature and ambient compensated, separately mounting and hand reset type. The reset push bottom for thermal overload relays shall be provided on the cover of the control panel so that it is possible to reset the relay from outside without opening the cover of the panel. Also indication shall be provided for hoisting/travel motors tripping on overload.

5.2.9 The panel shall be installed on properly levelled base frame fabricated out of channels of suitable size.

5.3 **Motors**

5.3.1 The design and specification of all motors shall comply with requirements stated elsewhere in the specifications.

5.3.2 The power rating of the motors shall be 25% higher than the design requirement of the driven equipment, under the specified service and duty conditions.
5.3.3 All motors shall preferably be of squirrel cage type and so designed that smooth acceleration or deceleration of the load is possible without any jerks. Further a maximum displacement of 2 mm when starting and stopping the motor in quick succession shall be guaranteed.

5.3.4 The motors for main hoist and micro hoist shall be suitable for intermittent duty type S4 with 60% C.D.E. and 300 starts / stops per hour. The motors for long travel and cross travel shall be suitable for S2 duty for 60 minutes.

5.3.5 The motors shall be so located that all parts are accessible for inspection and maintenance without affecting normal ventilation.

5.4 Brakes

5.4.1 The brakes for each motor shall be suitable for duties as specified below:

a) Main / Micro hoist S4 duty
b) Long / cross travel S2 duty

5.4.2 The coil of the brake shall be wound with fibre glass covered annealed copper conductor suitable for class H application. An additional covering with glass taps shall be provided over the coil. The maximum temperature of the coil for continuous operation shall be limited to 140º C. The coil shall be vacuum impregnated.

5.4.3 For other design details refer mechanical engineering standard.

5.5 Limit Switches

5.5.1 Limit switches of both shunt and series type shall be used in control and power circuit.

5.5.2 These shall be heavy duty type and of sturdy construction in cast aluminium enclosure.

5.5.3 The mode of operation of these limit switches shall be positive and direct acting type.

5.5.4 The contacts shall be rated 50% more than the required current ratings.

5.5.5 The width of the roller of limit switches shall be sufficient to avoid slippage of contact with the striker.

5.5.6 The striker provided for operating these limit switches shall have rubber padding on surface which will make contact with roller to actuate it. The limit switches and its roller should be designed to withstand the frequent impact pressure.

5.5.7 Switches in which the contacts are operated by spring or gravity or both on the withdrawal of a chain or similar devices, shall not be used.

5.6 Transformers

5.6.1 These shall be of dry type, class H insulated, air cooled, double wound and mounted inside the panel.

5.6.2 The transformers shall be provided with switch fuse unit on their primary side of suitable rating. One side of secondary windings of the transformers shall be earthed and other shall be provided with fuse of suitable rating.

5.6.3 The rating of the transformers shall be at least 2.5 times the continuous load.

5.7 Junction Box
Junction boxes shall be of cast aluminium construction and adequately sized to enable easy termination of cables.

5.8 **Hand Lamps**

5.8.1 Provision shall be made in the crane for use of hand lamps by installing 2 nos. 24 volts, 2 pin metal clad switch sockets. One of the sockets shall be on the bridge (outside the panel) and the other on the trolley.

5.8.2 The transformer primary and secondary voltage shall be 250V and 25V respectively.

6.0 **CABLES, CABLE TERMINATION AND CONNECTIONS**

6.1 The cables used for fixed wiring shall be 1.1 KV grade PVC insulated armoured and PVC sheathed overall, and shall conform to IS: 1554 Part-I.

6.2 The flexible cable used for power supply to crane and also for interconnection of equipment mounted on moving and fixed part of the crane shall be 1.1 KV grade heavy duty type.

6.3 All cables shall be properly laid and supported with adequately sized aluminium clamps at 500 mm interval.

6.4 Cable entry on all electrical equipment e.g. panels, motors, limit switches, brakes, junction boxes etc. shall be through double compression type rolled aluminium cable glands.

6.5 The internal power wiring of panels shall be carried out by PVC insulated stranded copper flexible cable.

6.6 The wiring shall be arranged in a neat fashion and supported on PVC channel or PVC stand of screw support.

6.7 For equipment mounted on the doors, the wiring shall be carried out with flexible stranded copper cables in such a way that no strain is put on the wires and equipment when the door is opened for inspection and maintenance.

6.8 External looping of wires shall be done through separate dust tight junction boxes.

6.9 The sizes of power cables to be used shall be subject to owner’s approval. The minimum size of power and control cables shall be 16 sq. mm (Al) & 2.5 sq. mm (Cu) respectively.

7.0 **EARTHING**

7.1 The earthing of all electrical equipment shall be carried out in accordance with IS: 3043.

7.2 The enclosures of electrical equipment shall be connected to an aluminium earth ring on the crane which in turn shall have effective electrical connection with the bridge.

7.3 The crane bridge shall be earthed through the bridge travel runway rails on both sides which in turn shall be earthed to owner’s earth ring located on the ground floor.

7.4 Further the power supply cable for the crane shall have an additional conductor for earth connection. Both sides of this conductor shall be earthed.
7.5 All earth conductors shall be of aluminium.

7.6 This size of earth conductor shall be equal to half the size of the power conductor subject to a minimum size of 10 sq. mm.

8.0 CONTROL DESK / CONTROL STATION

8.1 The crane shall be controlled either from the floor by means of a pendant control station or from bridge mounted control desk as indicated in the mechanical data sheet.

8.2 In either case, the units shall have the following control devices:
   - Main off push button with padlocking arrangement.
   - Indication lamps for supply ‘ON’
   - Control push buttons, as specified in the mechanical data sheet.
   - All other devices required for safe and proper operation of the crane / hoist.

8.3 All push buttons shall be momentary contact type, coloured as per IS: 6875 and have 1 NO and 1 NC contacts.

8.4 The bridge mounted control desk, where specified, shall be of totally enclosed and dust tight construction. All controlling equipment shall be mounted on the top. It shall be located at most convenient location to allow movement of the operator. The installation shall be equipped with adjustable chair, fan, light and main isolating switch.

8.5 The pendant control station, where specified, shall be in a single enclosure and in totally enclosed dust light execution. The unit shall be suspended and supported from the bridge platform by flexible steel wire rope. The connection shall be made with a multi core flexible copper conductor cable and shall have 20% spare cores. One core shall be provided for earth connection of the circuit.

9.0 PAINTING

Enclosures of all electrical equipment shall be painted with two coats of epoxy based primers after suitable pre-treatment. Two coats epoxy based paint of approved colour shall be provided.

10.0 TESTS AND INSPECTION

10.1 All equipment shall be routine tested as per relevant Indian Standard Specifications.

10.2 Additional tests, wherever specified, shall be carried out on one equipment of each rating.

10.3 All the above mentioned tests shall be carried out in presence of owner’s representative.

10.4 The owner’s inspection shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

10.5 Despatch of materials shall be subject to written consent of owner or his representative.

11.0 INSTALLATION, TESTING AND COMMISSIONING
11.1 The vendor shall undertake installation of all electrical equipment in accordance with latest code of practices, in conformity with recommendation of the respective equipment manufacturer, drawings approved by the owner or owner’s representative, direction of Engineer-in-charge, statutory regulations and to the entire satisfaction of the owner.

11.2 The vendor shall arrange all the necessary erection tools and tackles, testing and measuring instruments and shall supply the required erection materials including structural steel.

11.3 Following tests shall be specifically conducted before commissioning in presence of owner’s representative. All the test results shall be recorded and submitted to the owner.
   i) Insulation test.
   ii) Continuity test.
   iii) High voltage test.
   iv) Simulation test.

12.0 DRAWINGS AND DOCUMENTS

12.1 Drawings and documents as per Annexure-I shall be supplied unless otherwise specified.

12.2 All drawings and documents shall have the following description written boldly :
   - Name of client
   - Name of consultant
   - Enquiry / Order Number with plant / project name
   - Code No. and Description

13.0 SPARES

13.1 Spares for operation and maintenance
   Item wise unit prices of spare parts shall be quoted.

13.2 Commissioning Spares
   Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

13.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

13.4 All spare parts shall be identical to the parts used in the equipments.

14.0 DEVIATIONS

14.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
## ANNEXURE - I

### DOCUMENTATION FOR ELECTRICALS FOR OVERHEAD CRANES & HOISTS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Documents Required (Y / N)</th>
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<tr>
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<td>With Bid</td>
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<tr>
<td>1.</td>
<td>Specification sheet and technical particulars</td>
<td>N</td>
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<tr>
<td>2.</td>
<td>Composite schematic diagram</td>
<td>N</td>
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<tr>
<td>3.</td>
<td>Dimensional drawing showing the mounting details and general arrangement for</td>
<td>N</td>
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<td></td>
<td>the following equipment</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Motors</td>
<td>N</td>
</tr>
<tr>
<td>b)</td>
<td>Power control panel</td>
<td>N</td>
</tr>
<tr>
<td>c)</td>
<td>Control station</td>
<td>N</td>
</tr>
<tr>
<td>d)</td>
<td>Limit switches etc.</td>
<td>N</td>
</tr>
<tr>
<td>4.</td>
<td>Down shop lead and power supply arrangement with civil scope</td>
<td>N</td>
</tr>
<tr>
<td>5.</td>
<td>Inter-connection with terminal diagram and cable details</td>
<td>N</td>
</tr>
<tr>
<td>6.</td>
<td>Operating and maintenance instruction manual</td>
<td>N</td>
</tr>
<tr>
<td>7.</td>
<td>Catalogues of bought out items</td>
<td>N</td>
</tr>
<tr>
<td>8.</td>
<td>Test certificates</td>
<td>N</td>
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</tbody>
</table>

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

i) The tenderer shall also quote for any other spares as deemed necessary to be kept in stock for stipulated time.
TECHNICAL SPECIFICATION

HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM
## CONTENTS

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1.0 SCOPE

1.1 The scope of this specification is to define the minimum technical requirements for the design, manufacture, testing and supply of High Voltage, AC Variable Frequency Drive system. The VFD system shall be complete with Squirrel Cage Induction Motor/ Synchronous Motor as specified in data sheet, Converter, Converter input transformer, drive output transformer, DC link reactor with associated auxiliaries, harmonic filters and field mounted local motor control panel.

1.2 The Vendor shall be responsible for engineering and functioning of the complete system, meeting the intent and requirement of this specification and data sheets. This shall include but not be limited to inverter sizing, transformer sizing, transformer impedance selection, vector group, input and output harmonic filter design and sizing, output dv/dt filter sizing, motor cable selection and motor sizing/selection.

1.3 This specification applies to drive systems having converter input voltage above 1000 V AC and up to and including 11000V AC.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS, unless otherwise specified:

- IS:325 Three-phase Induction Motors
- IS:3700 Essential Ratings and Characteristics of Semiconductor Devices
- IS:3715 Letter symbols for semi-conducting devices
- IS:4411 Code of designation of semi-conducting devices
- IS:5001 Guide for preparation of drawings of semiconductor devices and Integrated Circuits
- IS:5469 Code of practice for the use of semiconductor Junction Devices
- IS:14901 Semi-conductor devices- Discrete devices & Integrated Circuits
- IS:15880 Three Phase Cage Induction motors when fed from IGBT Converters Application Guide
- IS:8789 Values of Performance characteristics for Three Phase induction motor
- IS: 12615 Energy Efficient Induction Motors - Three Phase Squirrel Cage
- IS:12729 Common specification for High-Voltage Switchgear and Control gear standards
- IEC:60 146-1-3 Semiconductor Convertors general requirements and line commutated converters-Transformer & reactors
- IEC:61800 Adjustable speed electrical power drive systems
- IEEE:519 Recommended Practices and requirements for Harmonics Control in Electrical power system

2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BSNDE/IEEE/NEMA or equivalent agency shall be applicable.
2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the following order of priority shall govern:

- Statutory regulations
- Data sheets
- Job specification
- This specification
- Codes and standards

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply

3.3 Vendor shall give a notice of at least one year to the end user of equipment before phasing out the product/spares to enable the end user for placement of order for spares and services.

3.4 Vendor shall ensure proper co-ordination with the driven equipment supplier in selection/sizing of offered variable frequency drive system.

4.0 SITE CONDITIONS

4.1 The drive system shall be designed to operate under specified site conditions as specified in the data sheets. If not specifically mentioned therein, a design ambient temperature of 50°C and an altitude not exceeding 1000 metres above mean sea level shall be considered.

4.2 The AC drive shall be installed indoors in a non-hazardous, air-conditioned or pressurized room, as specified in data sheet. Transformer installation (outdoor/ indoor) shall be as indicated in datasheet. Motor shall be installed outdoors in safe or hazardous area as specified in datasheet.

4.3 All the equipment shall be designed for continuous duty as per nameplate rating under the specified ambient conditions.

5.0 DESIGN AND FABRICATION REQUIREMENTS

5.1 Performance Requirement

5.1.1 The system shall be energy efficient, designed as standard product and shall provide very high reliability, high power factor, low harmonic distortion and low vibration/ wear / noise. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.

5.1.2 The system shall be designed to deliver the motor input current and torque for the complete speed torque characteristics of the driven equipment, with input supply variation of ±10% and frequency variation of ±3%. The system shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short-circuit.

5.1.3 The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment or specified in the data sheet:
5.1.4 The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The power control regulator logic shall provide for an acceleration/deceleration current limit curve and shall be capable of field adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.

5.1.5 The System shall be suitable for single quadrant operation and the speed variation shall be with range 10-100 % unless otherwise specified in data sheet with speed set accuracy of ±1% of rated maximum speed and steady state regulation of±0.5% of rated speed.

5.1.6 The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800 and same shall be considered in the design of the motor. The dv/dt limits & Vpeak shall also be as per IEC-61800-2.

5.1.7 Harmonics at the supply side of the drive system at primary of the main input transformer shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations in the latest edition of IEEE-519. The vendor shall perform design calculation for harmonic filter system considering VFD connected to the power system and including the supply of harmonic filters along with all accessories which shall be installed at owner's power system unless otherwise specified. These harmonic studies shall be conducted with maximum and minimum system fault level, cable capacitance, system equipment reactance etc. The studies shall highlight but not be limited to maximum load current, expected resonant frequencies, need of harmonic filters, sequence of switching of filters, voltage wave form, rating of equipments/ feeder for feeding filters from owner's switchgear etc.

5.1.8 Unless otherwise specified, the overload capacity of the controller shall be 150% of rated current of motor for one minute for constant torque applications, and 110% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demands exceed the current limit for more than 1 minute, the drive shall shutdown to prevent over heating of the motor and damage to the drive.

5.1.9 During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in speed set point within a time limit upto 60 seconds.

5.1.10 The integrator action of the speed set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustments by the distributed control system shall be considered as 10 seconds.

5.1.11 The drive shall trip in case the speed exceeds 105%of the maximum operational speed or reduces to 95% of the minimum operational speed for more than 10 seconds.

5.1.12 Maximum noise level from the drive at 1-meter distance, under rated load with all normal cooling fans operating shall not exceed 85 dBA.

5.1.13 Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for start up adjustments and troubleshooting/maintenance.
5.1.14 Voltage at motor neutral shall be maintained at ground potential for the total operating condition.

5.2 Control Requirement

5.2.1 The system shall operate on constant V/f supply with required voltage boost capability in low frequency mode of operation.

5.2.2 Short time voltage dips up to 20% of nominal voltage (e.g. in case of a large motor start up connected to the same bus as VFD) shall not cause the control system to stop functioning and shall not trip the drive system.

5.2.3 The system shall also be equipped with a momentary powerloss ride through feature which will restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value. The drive shall have the facility to block this feature, if required by the operator. Upon restart, the converter shall be capable of synchronizing onto a rotating motor and develop full acceleration torque within 10 seconds.

5.2.4 The system shall be suitable for number of starts as per attached specification for High Voltage Motors.

5.2.5 The power controller shall be controlled to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.

5.2.6 The drive motor shall be speed controlled corresponding to 4-20mA or 0-10 V reference input signal. Unless otherwise specified, upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed as at 80-100% of the last speed reference available prior to the loss of signal.

5.2.7 It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/Manual selection shall be from VFD panel unless otherwise specified.

a. With the selector switch in "manual" mode, the operator shall be able to set the speed through key pad (mounted on front of the drive panel) or from speed increase/decrease push buttons (from the field). Motor operated potentiometer shall be provided as a speed set point device.

b. With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's PLC/DCS (Process Control) system. Necessary equipment required for interfacing with PLC/DCS shall also be provided in the VFD panel.

c. Local/Remote selector switch shall be provided in local control station (in Field). With the selector switch in "Local" mode, the operator shall be able to start and set the speed through local control station (in Field). With the selector switch in "Remote" mode, speed of the motor shall be controlled either from VFD panel or from Owner's PLC/DCS as explained in a) and b) above.

5.2.8 The required provision for the interface with remote PLC/DCS located at control room shall be either through hardwired connection (with potential free contacts and transducers as described elsewhere in this specification) or through serial communication link as defined in the datasheet.

5.2.9 Drive system shall have provision for interface with upper level automation such as Substation monitoring system or electrical control system in case specified in the data sheet/job specification.
5.2.10 The closed loop control feedback for the drive system having output transformer shall be tapped from the secondary side of the output transformer.

5.3 Panel Construction

5.3.1 The panel shall include suitable semi-conducting power devices (Diodes/IGBT/IGCT/IEGT/SGCT) modules with protective devices, reactors (if required), filters, control circuit, control accessories, indication and annunciation etc. The construction of the panel shall provide effective protection against electromagnetic emissions and shall meet the design requirement of relevant standards.

5.3.2 Upstream breaker ‘ON/OFF/TRIP’ indications and remote breaker closing and trip push buttons shall be provided on the front door.

5.3.3 Safety Interlock shall be provided so that power cabinet can't be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.

5.3.4 The drive shall be suitably housed in sheet steel panels and shall be fabricated using cold rolled sheet steel. The sheet steel used for the panel shall be of minimum 2 mm CRCA. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-31. Maximum and minimum operating height shall be 1900 mm and 300 mm respectively.

5.3.5 Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm², and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 600mm clear from bottom of the cable gland plate.

5.3.6 Bus bars shall be of electrolytic copper/aluminium, sleeved, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate.

5.3.7 All the switches, component and accessories which are essential for normal and emergency operation shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, where provided, shall be switchboard type, back connected & of size 96x96mm. Scale shall have red mark indicating maximum permissible operating rating.

5.3.8 Each panel shall be provided with illuminating lamp/11 W CFL with switch and fuse. 5/15A, 240V power socket with switch and fuse shall be provided. Each panel shall have space heater with switch fuse and variable setting thermostat.

5.3.9 Copper earth bus of min. 30x6 sq.mm. upto short circuit withstand capacity of 31.5kA and 50x6 sq.mm. for a short circuit withstand capacity above 31.5kA shall be provided in the panel with provision for connection to owner's plant earth grid. All the non-metallic components/parts shall be connected to the main earth bus bar. Separate earth bus bar and stud for electronic control system if required shall be provided.

5.3.10 All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.

5.3.11 All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring
inside the panel shall be done with BIS approved, PVC insulated, fire retardant, low smoke, copper conductor wire 1.5mm² size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm² size for control fuse rating above 16 A for electrical circuits and 0.5mm² for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.

5.3.12 All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipments and power electronic equipments shall be used.

5.3.13 Low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment.

5.3.14 DC link capacitor and pre-charging & discharging circuit shall be preferably mounted in the rear of the panel.

5.3.15 Suitable eyebolts/ lifting clamps/ strap & cradle arrangement shall be provided for lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panel.

5.3.16 Acrylic type transparent insulating material shall be used for covering live components.

5.3.17 Drive keypad, operator control panel required for control, monitoring and measurements shall be supplied and installed outside the panel on the front door. It shall be accessible for operation without opening the front door and shall be non-removable type.

5.3.18 All equipment shall be complete with cable glands, lugs etc. and cable glands shall be single or double compression type for indoor and outdoor equipment respectively. Cable glands shall also be suitable for the hazardous area application if specified in data sheet.

5.4 Cooling

5.4.1 The drive panel shall be naturally cooled or water cooled type as per manufacturer's standards. However, it is preferred to have natural air cooled system. If unavoidable, forced type-cooling system shall be provided. Cooling system shall include well-dimensioned panel, adequate cooling airflow path, modular cooling fan and if necessary, panel cooling fan or water-cooling system shall be considered. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N+1) shall be provided. In case redundant cooling fan is not possible to be mounted in the panel, same shall be supplied loose.

5.4.2 For water-cooled drives, entire cooling system including but not limited to heat exchanger, flow and pressure meters and pumps shall be in vendor's scope. The system shall be provided with closed circuit water cooling system, requiring only make up water required for topping up. The cooling water pumps, in case provided, shall have 100% redundancy. Water quality/characteristics shall be as defined in the data sheet and selected cooling water system components/material shall be suitable for the same. Adequate safety measures shall be incorporated in water cooled drives such that no leakage is there which results in malfunctioning of electronic devices. Proper segregation between water cooling system and other equipment shall be provided. It is preferred that cooling cabinet panel shall be separated from the main panels.

5.4.3 Necessary starters shall be provided within the VFD panels for the Ventilation fans, Cooling Water circulation pumps, any other auxiliary motor etc. The system provided shall be interfaced with drive starting and shutdown so that safety interlocks such as start permit from
cooling system to drive and trip signal from cooling system to drive in case of cooling system failure etc., are incorporated in the overall sequence logic.

5.4.4 MCB for motor space heater, auxiliary power supply if required for local panel, drive panel space heater etc. shall be included and mounted in easy accessible location.

5.5 Equipment/ Component Specification

5.5.1 Motor

The motor shall be designed, constructed and tested in accordance with the latest revision of Specification /data sheet for High Voltage Induction / Synchronous Motor, in addition to the following requirements:

a. The motor shall be suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control.

b. The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.

c. The motor shall be designed to operate continuously at any speed over the range (10-100%) of rated speed unless otherwise specified in data sheet.

d. The permitted voltage variation should take into account the steady state voltage drop across the AC drive and all other system components upstream of the motor.

e. Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in system line voltage and frequency. Starting current of motor in DOL bypass mode shall be limited to value specified in motor specifications, unless otherwise specified in datasheets.

f. The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.

g. The motor insulation shall be designed to accept the applied voltage waveform, within the Vpeak and dv/dt limits as per IEC-61800-4 and necessary co-ordination between the VPD manufacturer & motor manufacturer W.r.t. incorporation of VPD output parameter in the design of motor shall be carried out.

h. The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.

i. Motors shall be provided with Resistance Temperature Detectors (RTDs).

5.5.2 Converter Transformer/ Output transformer

a. The converter transformer shall be dry type or oil filled type as specified in the data sheet. In case of the dry type transformer, it shall be mounted in the drive system panel unless specified otherwise in the datasheet. Offered transformer shall be as per enclosed Specifications/data sheet.

b. The impedances of converter input transformers with more than one secondary windings for 12/18/24/36 pulse systems shall be selected to ensure equal load/current sharing between the secondary windings, the converters and the motor windings under all operational conditions including starting and restarting.
c. Drive output transformer considered only for the purpose of meeting standard rated motor voltage i.e. 3300, 6600V, 11000V shall not be provided unless otherwise agreed between purchaser and the manufacturer.

5.5.3 Power Converter

a. The static power converter shall consist of a line side power converter for operation as a rectifier and a load side power converter for operation as a fully controlled inverter. Power converter shall be fast switching, most efficient and low loss type.

b. Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.

c. All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.

d. The current rating of the converter’s semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the entire speed range.

e. All power diodes shall be of silicon type with minimum $V_{BO}$ rating as 2.5 times the rated operating voltage.

f. The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise due to harmonic currents generated by the inverter operation.

g. The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions/tools.

h. The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.

i. Offered system shall also take into account the distance between Drive panel and motor and system shall include all material and accessories to make system suitable for a distance of 350m unless otherwise specified in the data sheet.

5.5.4 DC Link Reactor

a. Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit.

b. Unless otherwise specified, the reactor shall be air-cooled or fan cooled type located within the panel.

c. Reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.

5.5.5 Output Filter

VFD output current waveform should be inherently sinusoidal at all speeds, with harmonic limits as specified in this specification. Output filter shall be provided, if required. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is
reduced to less than 50 V DC within 300 seconds after a loss of AC voltage. All capacitor shall be maintenance-free and self-healing type. The VFD system shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

5.5.6 Bypass Feature

a. Bypass feature along with motor protection relay and output side isolator/breaker shall be provided by purchaser unless otherwise specified in the datasheet. All necessary interlocks as required for safe and reliable operation of VFD system along with bypass feeder and output side isolator/breaker provided by Purchaser shall be provided in VFD system.

b. Bypass starter shall be in separate compartment and switching scheme shall be such that in case of drive mal-operation, the motor could be taken on bypass control manually, while the drive could be attended independently. Suitable interlock shall be provided such that bypass mode and VFD mode shall not operate simultaneously.

5.5.7 Local Motor Control Station

a. The local motor control station, to be installed in the field near the motor shall conform to the attached specifications. Components and accessories that are required in the local motor control station may be mounted on the local field mounted panel envisaged for the driven equipment.

b. Meters in the local control station shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current. Further, for drives with bypass facility, the meters shall be capable of reading bypass mode full load and starting currents as well as the VFD mode drive current.

5.6 Protection, Control, Metering, Indication and Annunciation

5.6.1 The system vendor shall provide all the necessary system control, protection, alarm and metering equipment for the entire drive system and its auxiliary equipment.

5.6.2 Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.

5.6.3 Operator Control Panel

a. Each drive shall be equipped with a front mounted operator control console consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to Start/Stop, Local/Remote, Auto/Manual, Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.

b. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand the display without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However, the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.
c. Operator console shall have facility/ port to connect external hardware such as Laptop etc. Console shall have facility to upload and download all parameter settings from one drive to another identical drive for start-up and operation.

d. Drive system control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing upstream breaker after all required process parameters are achieved.

e. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.

5.6.4 Protective Features

The system shall incorporate adequate protective features, properly coordinated for the drive control and for the motor but not limited to the following:

I. Incoming line surge protection
II. Under / Over voltage protection
III. Phase loss protection.
IV. Programmable over current protection and under load protection.
V. Inverter Fault.
VI. Over frequency/Over speed of motor
VII. Ventilation loss (In case same is not provided, drive shall generate an over temperature fault alarm and suitable sensors, as required for same, shall be provided).
VIII. Over temperature of equipment.
IX. Specific motor protection, including motor winding, bearing temperatures, over current, overload, negative phase sequence and earth fault protections etc.
X. System earth fault protection.
XI. Excitation system protection for synchronous motor
XII. Over and under frequency, rotor earth fault (if applicable), field failure protection for synchronous motor
XIII. Additional protection, if any for the drive system

5.6.5 Control

The following controls shall be provided as a part of the Operator Control Panel or through separate switches.

I. Start/Stop
II. Speed control (Raise/Lower)
III. Forward/Reverse (if specified)
IV. Auto/Manual /Test mode
V. Local/Remote
VI. Emergency stop
VII. Start/Stop for bypass starter (where specified)
VIII. Trip-Remote Breaker
IX. Excitation control system for synchronous motors
X. Sequential switching of filters

5.6.6 Indications

Vendor shall provide indications as required for normal operation and for ease of maintenance, which shall not be limited to the following indications.

I. Motor running
II. Motor stopped
III. VFD System Fault
IV. System ready to start
V. AC mains ON
VI. Motor over speed
VII. Rectifier output 'ON'
VIII. Motor zero speed
IX. Remote breaker trip
X. Excitation system healthy for synchronous motors

Above indications may be provided as a part of the operator control panel, i.e. door mounted keypad or through hardwired LEDs. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2 Nos LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm.

Potential free contacts for items i to iv shall be wired separately for remote indications in DCS system.

5.6.7 Metering

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

I. Output voltage
II. Output current-VFD model Bypass mode
III. Output frequency
IV. Drive thermal state
V. Motor speed
VI. Motor energy meter
VII. Hour Run
VIII. Voltage and current meter for excitation system of synchronous motor
IX. KVAR, power factor meter for synchronous motors
X. Necessary transducer shall be provided with 4-20mA output for indicating motor speed and motor current in DCS unless otherwise specified for other parameters.

5.7 Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including, shutdown of the system, shall be available for a period of minimum 4 days (96 hours) after a shutdown, even though no supply would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

5.8 External Power supply for auxiliary and Control Circuit

Auxiliary power supply for devices external to VFD module, space heater supply for Motor, VFD panel space heater, auxiliary power supply for transformers, cubicle 11W CFL lamps, indicating lamps, digital meters (Ammeter, Speedometer) etc. shall operate on 240 volts single phase AC supply provided by purchaser.

All control circuit shall operate at maximum voltage of 240V AC or 220V DC unless otherwise specified in the datasheet.

Vendor shall include supply of all control transformers, protective devices, associated
accessories etc. and any other control supply voltage required for the system shall be derived by the vendor from the power supply made available by purchaser.

5.9 Reliability Features

The expected lifetime of the drive system shall be min. 20 years. The system including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years.

5.10 Maintenance features

The controller design shall incorporate the following maintenance features:

- Modular construction
- All components shall be easily accessible.
- Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

5.11 Painting

5.11.1 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL 7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.11.2 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the drive shall be subject to inspection by PDIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used.

6.2 All tests shall be carried out at the manufacturer's works under his care and expense. The tests shall be witnessed by an inspector of PDIL/Owner or of an agency authorized by the owner. Prior notice of minimum 4 weeks shall be given to the inspector for witnessing the tests.

6.3 All Routine & Type Tests shall be conducted as per the NIT for HV variable frequency drive 6-81-1050 as per IEC 61800-2. However, combined test for VFD and motor at vendor's works shall be carried out if specified in the datasheet.

6.4 String Test with driven equipment

If a string test with driven equipment is specified in the data sheet of the driven equipment, it shall be carried out with the job equipment.

7.0 SPARES

7.1 Spares for operation and maintenance

Item wise unit prices of spare parts shall be quoted.

7.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.
7.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

7.4 All spare parts shall be identical to the parts used in the switch boards.

8.0 DRAWINGS

8.1 Vendor shall submit to Purchaser, for approval, before completion of manufacturing and assembly of equipment following drawings and literature.

   (i) Installation and maintenance manual including trouble-shooting chart.
   (ii) Panel drawings and cable schedule
   (iii) Block diagram and control logic.

9.0 CERTIFICATION

The motors and associated Variable frequency drive system equipment shall have test certificates issued by recognized independent test house (CIMFRI BASEEFA/ LCIE/UL/FM or equivalent). All indigenous motors shall conform to Indian Standards and shall be certified by Indian testing agencies. All motors (indigenous and imported) shall also have valid statutory approvals as applicable for the specified hazardous location. All indigenous flameproof motors shall have valid BIS license and marking as required by statutory authorities.

Also the motor nameplate shall clearly indicate that the motor is suitable for operation with variable frequency drive along with VFD make and model number.

10.0 PACKING AND DESPATCH

All the equipment shall be divided into several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO nos.' etc., shall be clearly marked on the package together with other details as per purchaser for scrutiny. The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains/high ambient temperature.
TECHNICAL SPECIFICATION

MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM
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1.0 SCOPE

1.1 The scope of this specification is to define the minimum technical requirements for the design, manufacture, testing and supply of Medium Voltage, AC Variable Frequency Drive system. The VFD system shall be complete with Squirrel Cage Induction Motor/ Synchronous Motor as specified in data sheet, Converter, Converter input transformer, drive output transformer, DC link reactor with associated auxiliaries, harmonic filters and field mounted local motor control panel.

1.2 The Vendor shall be responsible for engineering and functioning of the complete system, meeting the intent and requirement of this specification and data sheets. This shall include but not be limited to inverter sizing, transformer sizing, transformer impedance selection, vector group, input and output harmonic filter design and sizing, output dv/dt filter sizing, motor cable selection and motor sizing/selection.

1.3 This specification applies to drives connected to line voltage up to 1000 V, AC.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS, unless otherwise specified:

- IS:325 Three-phase Induction Motors
- IS:3700 Essential Ratings and Characteristics of Semiconductor Devices
- IS:3715 Letter symbols for semi-conducting devices
- IS:4411 Code of designation of semi-conducting devices
- IS:5001 Guide for preparation of drawings of semiconductor devices and Integrated Circuits
- IS:5469 Code of practice for the use of semiconductor Junction Devices
- IS:14901 Semi-conductor devices - Discrete devices & Integrated Circuits
- IS:15880 Three Phase Cage Induction motors when fed from IGBT Converters Application Guide
- IS:8789 Values of Performance characteristics for Three Phase induction motor
- IS: 12615 Energy Efficient Induction Motors - Three Phase Squirrel Cage
- IEC:60947 Low Voltage Switchgear and Control gear
- IEC:60 146-1-3 Semiconductor Convertors general requirements and line commutated convertors-Transformer & reactors
- IEC:61800 Adjustable speed electrical power drive systems
- IEEE:519 Recommended Practices and requirements for Harmonics Control in Electrical power system

2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BSNDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulations the following order of priority shall govern:
3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment before phasing out the product/spares to enable the end user for placement of order for spares and services.

3.4 The vendor shall be responsible for design, engineering and manufacturing of the complete VFD system to fully meet the intent and requirements of this specification and attached data sheets.

4.0 SITE CONDITIONS

4.1 The AC drive system shall be designed to operate under specified site conditions as specified in the data sheets. If not specifically mentioned therein, a design ambient temperature of 50°C and an altitude not exceeding 1000 metres above mean sea level shall be considered.

4.2 The AC drive shall be installed indoors in a non-hazardous, air-conditioned or pressurized room, as specified in data sheet.

4.3 All the equipment shall be designed for continuous duty as per nameplate rating under the specified ambient conditions.

5.0 DESIGN AND FABRICATION REQUIREMENTS

5.1 Performance Requirement

5.1.1 The system shall be energy efficient, designed as standard product and shall provide very high reliability, high power factor, low harmonic distortion and low vibration/wear/noise. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.

5.1.2 The system shall be designed to deliver the motor input current and torque for the complete speed torque characteristics of the driven equipment, with input supply variation of ±10% and frequency variation of ±3%. The system shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short-circuit.

5.1.3 The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment or specified in the data sheet:

   a. Variable torque changing as a function of speed i.e. Speed squared
   b. Constant torque over a specific speed range
   c. Constant power over a specific speed range where the torque decreases when speed increases
   d. Any other as specified in data sheet
5.1.4 The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The power control regulator logic shall provide for an acceleration/deceleration current limit curve and shall be capable of field adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.

5.1.5 The System shall be suitable for single quadrant operation and the speed variation shall be with range 1:100 unless otherwise specified in data sheet with speed set accuracy of ±1% of rated maximum speed and steady state regulation of ±0.5% of rated speed.

5.1.6 The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800 and same shall be considered in the design of the motor. The dv/dt limits & Vpeak shall also be as per IEC-61800-2.

5.1.7 Harmonics at the supply side of the drive system at primary of the main input transformer shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations in the latest edition of IEEE-519. The vendor shall perform design calculation for harmonic filter system considering VFD connected to the power system and including the supply of harmonic filters along with all accessories which shall be installed at owner's power system unless otherwise specified. These harmonic studies shall be conducted with maximum and minimum system fault level, cable capacitance, system equipment reactance etc.

5.1.8 The controller output overload capacity shall be 150% of rated current of motor for one minute for constant torque applications, and 110% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demand exceeds the current limit for more than 1 minute, the drive shall shut down to prevent over heating of the motor and damage to the drive.

5.1.9 During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in speed set point within a time limit upto 60 seconds.

5.1.10 The integrator action of the speed set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustments by the distributed control system shall be considered as 10 seconds.

5.1.11 The drive shall trip in case the speed exceeds 105% of the maximum operational speed or reduces to 95% of the minimum operational speed for more than 10 seconds.

5.1.12 Maximum noise level at the drive at 1-meter distance, under rated load with all normal cooling fans operating shall not exceed 85 dBA.

5.1.13 Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for start up adjustments and troubleshooting/ maintenance.

5.2 Control Requirement

5.2.1 The system shall operate on constant V/f supply with required voltage boost capability in low frequency mode of operation.

5.2.2 Short time voltage dips up to 20% of nominal voltage (e.g. in case of a large motor start up connected to the same bus as VFD) shall not cause the control system to stop functioning and shall not trip the drive system.
5.2.3 The system shall also be equipped with a momentary powerloss ride through feature which will restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value. The drive shall have the facility to block this feature, if required by the operator. Upon restart, the converter shall be capable of synchronizing onto a rotating motor and develop full acceleration torque within 10 seconds.

5.2.4 The system shall be suitable for number of starts as per attached specification for Medium Voltage Motors.

5.2.5 The power controller shall be regulated to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.

5.2.6 The drive motor shall be speed controlled corresponding to 4-20mA or 0-10 V reference input signal. Upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed as at 80-100% of the last speed reference available prior to the loss of signal.

5.2.7 It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/Manual selection shall be from VFD panel unless otherwise specified.

   a. With the selector switch in "manual" mode, the operator shall be able to set the speed through key pad (mounted on front of the drive panel) or from speed increase/decrease push buttons (from the field). Motor operated potentiometer shall be provided as a speed set point device.

   b. With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's PLC/DCS (Process Control) system. Necessary equipment required for interfacing with PLC/DCS shall also be provided in the VFD panel.

   c. Local/Remote selector switch shall be provided in local control station (in Field). With the selector switch in "Local" mode, the operator shall be able to start and set the speed through local control station (in Field). With the selector switch in "Remote" mode, speed of the motor shall be controlled either from VFD panel or from Owner's PLC/DCS as explained in a) and b) above.

5.2.8 The required provision for the interface with PLC/DCS (located at remote control room) including the details of communication module and data transfer facility, 1/0 details shall be furnished. The communication interface shall be via serial communication link with industry standard open protocol i.e. MODBUS/IEC-61850/ RS-485 etc. and same shall be coordinated with the interfacing equipment. In case the vendor is using their proprietary software, the interface software for use with owner's system (software) shall be provided.

5.2.9 Drive system shall have provision for interface with upper level automation such as Substation monitoring system or electrical control system in case specified in the data sheet/job specification.

5.2.10 The closed loop control feedback for the drive system having output transformer shall be tapped from the secondary side of the output transformer.

5.3 Panel Construction

5.3.1 The panel shall include suitable isolating device (i.e. Circuit breaker/MCCB/ Switch fuse) for main supply, contactors, semi conducting power devices (Diodes / IGBT) modules with protective devices, reactors, filters, output isolating device, control circuit, control accessories, indication and annunciation etc.
5.3.2 Main isolating device shall function as a manual disconnect and shall be an AC thermal magnetic circuit breaker or a fused switch with dual element fuse to trip automatically on fault currents, as specified in data sheet. Devices shall be lockable in the open position and shall have a minimum interrupting capacity as specified in data sheet. Interlock shall be provided between the door, so that door cannot be opened unless the breaker/switch is open.

5.3.3 Safety Interlock shall be provided so that power cabinet can't be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.

5.3.4 The drive shall be suitably housed in sheet steel panels and shall be fabricated using cold rolled sheet steel. The sheet steel used for the panel shall be of minimum 2 mm CRCA except the doors & covers that may be made of 2mm CRCA. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-31. Maximum and minimum operating height shall be 1900 mm and 300 mm respectively.

5.3.5 Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm² and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 300mm clear.

5.3.6 Bus bars shall be of electrolytic copper/aluminium, sleeved, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.

5.3.7 All the power and control switches shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, wherever provided, shall be switch board type, back connected, 96x96mm size. Scale shall have red mark indicating maximum permissible operating rating.

5.3.8 Each panel shall be provided with illuminating lamp/Il W CFL with switch and fuse. 5/15A, 240V power socket with switch and fuse shall be provided. Each panel shall have space heater with switch fuse and variable setting thermostat.

5.3.9 Copper earth bus of min. 30X6 mm size shall be provided at the bottom of the panel extending outside the panel on both sides. All the non-metallic components/parts shall be connected to the main earth bus bar. In case a separate earth bus for electronic control system is required, the same shall be indicated in the drawings.

5.3.10 All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.

5.3.11 All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with BIS approved, PVC insulated, fire retardant, low smoke, copper conductor wire 1.5mm² size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm² size for control fuse rating above 16 A for electrical circuits and 0.5mm² for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.
5.3.12 All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipments and power electronic equipments shall be used.

5.3.13 DC link capacitor and pre-charging & discharging circuit shall be preferably mounted in the rear of the panel.

5.3.14 Suitable eyebolts/ lifting clamps/ strap & cradle arrangement shall be provided for lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panel.

5.3.15 Acrylic type transparent insulating material shall be used for covering live components.

5.3.16 All equipment shall be complete with cable glands, lugs etc. and cable glands shall be single or double compression type for indoor and outdoor equipment respectively. Cable glands shall also be suitable for the hazardous area application if specified in data sheet.

5.4 Cooling

5.4.1 Cooling system shall include well-dimensioned panel, adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N+1) shall be provided. Necessary starters shall be provided within the VFD panels for these fans. In case redundant cooling fan is not possible to be mounted, same shall be supplied loose.

5.4.2 MCB for motor space heater, auxiliary power supply if required for local panel, drive panel space heater etc. shall be included and mounted in easy accessible location.

5.5 Equipment/ Component Specification

5.5.1 Motor

The motor shall be designed, constructed and tested in accordance with the attached standard specification for Medium Voltage Induction Motor, in addition to the following requirements:

a. The motor shall be suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control.

b. The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.

c. The motor shall be designed to operate continuously at any speed over the range (10-100%) of rated speed unless otherwise specified in data sheet.

d. Motor shall be provided with thermistor type temperature detector

e. The motors shall be provided with Class 'F' insulation with temperature rise limited to Class ‘B’.

f. The permitted voltage variation should take into account the steady state voltage drop across the AC drive and all other system components upstream of the motor.

g. Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in system line voltage and frequency. Starting current of motor in DOL bypass mode shall be limited to value specified in motor specifications, unless otherwise specified in datasheets.
h. The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.

i. The motor insulation shall be designed to accept the applied voltage waveform, within the Vpeak and dv/dt limits as per IEC-61800-2.

j. The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.

k. Motors shall be provided with Resistance Temperature Detectors (RTDs).

l. Induced voltage at the shaft end of the motor at no load shall not exceed 250 mV rms for roller and ball bearings and 400 mV for sleeve bearings. The non driving end bearing shall be insulated from the motor frame to avoid circulating current. The insulated bearing end shield or pedestal shall bear a prominent warning.

5.5.2 Converter Transformer/ Output transformer

The converter transformer shall be suitable for use with the variable frequency drive system. The impedances of transformers with two secondary windings for 12 pulse systems shall be selected to ensure equal load/current sharing between the two secondary windings, the converters and the motor windings under all operational conditions including starting and restarting. The transformer shall be provided with ± 5% off circuit taps in steps of ± 2.5%.

5.5.3 Power Converter

a. The static power converter shall consist of a line side power converter for operation as a rectifier and a load side power converter for operation as a fully controlled inverter. Power converter shall be fast switching, most efficient and low loss type.

a. Normally, for all output short circuits, the inverter shall interrupt the current before any semi-conductor fuse blows. For internal short circuits, semi-conductor fuse protection shall be provided, and for faults upstream of semi-conductor fuses, the converter shall be able to withstand a three-phase short circuit current until interrupted by normal breaker operation. In case of fuseless design, the failure shall be limited to the particular device, without causing any damage to other parts of the power module. There must be clear annunciation of the failure of the device.

b. All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.

c. The current rating of the converter's semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the entire speed range.

d. All power diodes shall be of silicon type with minimum VBO rating as 2.5 times the rated operating voltage.

e. The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise due to harmonic currents generated by the inverter operation.

f. The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions/tools.
g. The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.

h. All the power transistors, thyristors and diodes shall be protected with high-speed semiconductor grade fuse. I2t particulars of the power controller devices and the fuses shall be properly co-ordinated for the selection of fuses.

5.5.4 DC Link Reactor

a. Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit. AC line reactors, if provided as per standard vendor design, shall be suitable for harmonic suppression and fault current limitation.

b. The reactor shall be dry type, air cooled or fan cooled type located within the panel. In case of fan cooled type, operation of fans shall be monitored.

c. Reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.

5.5.5 Output Filter

VFD output current waveform shall be inherently sinusoidal at all speeds, with harmonic limits as per C1.5.1.6. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 60 seconds after a loss of AC voltage. The VFD system shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

5.5.6 Bypass Feature

5.5.6.1 Output contactor/Load Break Switch shall be provided for isolation between the output of the controller and the motor for VFD systems with Bypass feature.

5.5.6.2 Bypass feature shall be provided, if specified in the data sheet. Accordingly Bypass feature with Bypass starter shall meet the following requirements, unless otherwise specified in the data sheet:

Bypass starter shall comprise of switch-fuse, contactor, bimetal relay meeting the requirements of Type-2 coordination as per IS/IEC-60947. CBCT and ELR shall be provided for motors rated above 22kW & upto 55kW unless otherwise specified in the data sheet. Heavy duty starters shall be provided with saturable type current transformer operated overload relay only, which shall be suitable for motor starting time of 15-60 seconds. For motors rated above 55kW, ACB/MCCB and motor protection relay along with necessary metering shall be provided.

Bypass starter shall be in separate compartment and it shall be possible to isolate and maintain the VFD while drive motor runs in Bypass mode. Three contactors/ breakers shall be used for this purpose, one contactor in the bypass and two contactors across the drive, such that in case of drive mal-operation, the motor could be taken on bypass control, while the drive could be attended by opening its contactors. Suitable interlock shall be provided such that bypass mode and VFD mode shall not operate simultaneously.

5.5.7 Local Motor Control Station
a. The local motor control station, to be installed in the field near the motor shall conform to the attached specifications. Components and accessories that are required in the local motor control station may be mounted on the local field mounted panel envisaged for the driven equipment.

b. Meters in the local control station for motors rated above 5.5kW shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current unless specified otherwise. Further, for drives with bypass facility, the meters shall be capable of reading bypass full load and starting currents, as well as the drive current. Local-off-Remote selector switch shall be provided in the LCS for selection of control from Local (i.e. LCS in Field) and Remote (i.e. from VFD panel / DCS / PLC).

5.6 Protection, Control, Metering, Indication and Annunciation

5.6.1 The system vendor shall provide all the necessary system control, protection, alarm and metering equipment for the entire drive system and its auxiliary equipment.

5.6.2 Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.

5.6.3 Operator Control Panel

a. Each drive shall be equipped with a front mounted operator control console consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to Start/Stop, Local/Remote, Auto/Manual, Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.

b. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand the display without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However, the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.

c. Operator console shall have facility/ port to connect external hardware such as Laptop etc. Console shall have facility to upload and download all parameter settings from one drive to another identical drive for start-up and operation.

d. Drive system control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing upstream breaker after all required process parameters are achieved.

e. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.

5.6.4 Protective Features

The system shall incorporate adequate protective features, properly coordinated for the drive control and for the motor but not limited to the following:

I. Incoming line surge protection
II. Under / Over voltage protection
III. Phase loss protection.
IV. Programmable over current protection and under load protection.
V. Inverter Fault.
VI. Over frequency/Over speed of motor
VII. Ventilation loss (In case same is not provided, drive shall generate an over temperature fault alarm and suitable sensors, as required for same, shall be provided).
VIII. Over temperature of equipment.
IX. Specific motor protection, including motor winding, bearing temperatures, over current, overload, negative phase sequence and earth fault protections etc.
X. System earth fault protection.
XI. Excitation system protection for synchronous motor
XII. Over and under frequency, rotor earth fault (if applicable), field failure protection for synchronous motor
XIII. Additional protection, if any for the drive system

5.6.5 Alarms

The system shall incorporate protection alarms, required for various fault conditions, for the Drive motor, Supply cables, Converter Transformer, DC Reactor and the Converter. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.

5.6.6 Control

The following controls shall be provided as a part of the Operator Control Panel or through separate switches.

I. Start/Stop
II. Speed control (Raise/Lower)
III. Forward/Reverse (if specified)
IV. Auto/Manual /Test mode
V. Local/Remote
VI. Emergency stop
VII. Start/Stop for bypass starter (where specified)
VIII. Trip-Remote Breaker
IX. Excitation control system for synchronous motors
X. Sequential switching of filters

5.6.7 Indications

Vendor shall provide indications as required for normal operation and for ease of maintenance, which shall not be limited to the following indications.

I. Motor running
II. Motor stopped
III. VFD System Fault
IV. System ready to start
V. AC mains ON
VI. Motor over speed
VII. Rectifier output ’ON’
VIII. Motor zero speed
IX. Remote breaker trip
X. Excitation system healthy for synchronous motors

Above indications may be provided as a part of the operator control panel, i.e. door mounted keypad or through hardwired LEDs. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2 Nos LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm. Potential free contacts for items i to iv shall be wired separately for remote indications in DCS system.

5.6.8 Metering

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

I. Output voltage
II. Output current-VFD model Bypass mode
III. Output frequency
IV. Drive thermal state
V. Motor speed
VI. Motor energy meter
VII. Hour Run
VIII. Voltage and current meter for excitation system of synchronous motor
IX. KVAR, power factor meter for synchronous motors
X. Speed and motor current in DCS unless otherwise specified for other parameters.

5.6.9 Annunciations

Potential free contacts shall be provided for following annunciations and shall be wired up to terminal block for owner's use for remote monitoring:

I. Rectifier fuse failure/Drive fault
II. Main AC failure
III. Inverter fuse failure/Drive fault
IV. Inverter overload
V. Inverter high temperature/Drive fault
VI. Failure of panel cooling system
VII. Motor failed to start/Drive fault

All drive internal faults will be annunciated as drive fault.

5.7 Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including, shutdown of the system, shall be available for a period of minimum 4 days (96 hours) after a shutdown, even though no supply would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

5.8 External Power supply for auxiliary and Control Circuit
Control supply for devices external to VFD module i.e. contactors control, space heater supply for Motor / VFD, indicating lamps digital meters (Ammeter, Speedometer) etc. shall operate on 240 V control supply derived from single-phase control supply transformer, with switchfuse provided in primary and MCB in secondary, located inside the drive controller.

5.9 Reliability Features

The expected lifetime of the VFD shall be minimum 20 years. The VFD including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years.

The controller design shall incorporate the following reliability features:

- Pre-tested components with power components to be 100% tested under dynamic conditions.
- Printed circuit boards shall be computer tested and adjusted.
- Printed circuit boards shall be temperature cycled for a minimum of 40 hours.
- Printed circuit boards shall be treated for tropical, humid and corrosive environment.

5.10 Maintenance features

The controller design shall incorporate the following maintenance features:

- Modular construction
- Printed circuit boards shall be plug connected.
- All components shall be easily accessible.
- Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

5.11 Painting

5.11.1 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The color shade of final paint shall be as RAL 7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.11.2 All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finishing coat.

5.11.3 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 All tests shall be carried out at the manufacturer's works under his care and expense. The tests shall be witnessed by an inspector of PDIL/Owner or of an agency authorized by the owner. Prior notice of minimum 4 weeks shall be given to the inspector for witnessing the tests.

6.2 During fabrication, the drive shall be subject to inspection by PDIL/Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used.
6.3 All Routine & Type Tests shall be conducted as per the NIT for HV variable frequency drive 6-81-1050 as per IEC 61800-2. However, combined test for VFD and motor at vendor's works shall be carried out if specified in the datasheet.

6.4 String Test with driven equipment

If a string test with driven equipment is specified in the data sheet of the driven equipment, it shall be carried out with the job equipment.

7.0 SPARES

7.1 Spares for operation and maintenance

Item wise unit prices of spare parts shall be quoted.

7.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

7.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

7.4 All spare parts shall be identical to the parts used in the switch boards.

8.0 DRAWINGS

Vendor shall submit to Purchaser, for approval, before completion of manufacturing and assembly of equipment following drawings and literature.

(i) Installation and maintenance manual including trouble-shooting chart.
(ii) Panel drawings and cable schedule
(iii) Block diagram and control logic.

9.0 CERTIFICATION

The motors and associated Variable frequency drive system equipment shall have test certificates issued by recognized independent test house (CIMFR BASEEFA/ LCIE/UL/FM or equivalent). All indigenous motors shall conform to Indian Standards and shall be certified by Indian testing agencies. All motors (indigenous and imported) shall also have valid statutory approvals as applicable for the specified hazardous location. All indigenous flameproof motors shall have valid BIS license and marking as required by statutory authorities.

Also the motor nameplate shall clearly indicate that the motor is suitable for operation with variable frequency drive along with VFD make and model number.

10.0 PACKING AND DESPATCH

All the equipment shall be divided into several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO nos. etc., shall be clearly marked on the package together with other details as per purchaser for scrutiny. The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains/high ambient temperature.
TECHNICAL SPECIFICATION
COMMUNICATION AND FIRE ALARM CABLES
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1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture and supply of Flame Retardant type PVC sheathed cables for use in plant communication and fire alarm systems and Jelly filled telecommunication cables.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of the latest revision of the following standards issued by BIS and DOT, unless otherwise specified:

2.1.1 BIS standards:

- **IS-694**: PVC insulated cables for working voltages upto and including 1100V.
- **IS-1554 (Part-I)**: PVC insulated (heavy duty) electric cables-(Part-I for working voltages up to and including 1100V).
- **IS-5831**: PVC insulation and sheath of electric cable.
- **IS-8130**: Conductors for insulated cables and flexible cords.
- **IS-9938**: Recommended Colours for PVC insulation for LF wires and cables.
- **IS-10418**: Drums for electric cables.
- **IS-10462 (Part-1)**: Fictitious calculation method for determination of dimensions of protective coverings of cables:(Part-I Elastomeric and thermoplastic insulated cables).
- **IS-10810 (Part- 61)**: Methods of test for cables (Part 61. Flame retardant test)
- **IS-12444**: Continuously cast and rolled electrolytic copper wire rods for electrical conductors.

2.2 DOT Standards:

- **GRJWIR-06/03**: Specification for cable - switchboard (Screened and Unscreened) Generic Requirements.
- **G/CUG-O1/02**: Specification for solid polythene insulated fully filled, Polythene sheathed underground telecom cables.

2.3 In case of imported cables, standards of the country of origin shall be applicable, if these standards are equivalent to or stringent than the applicable Indian standards.

2.4 The cables shall also conform to the provisions of the Indian Electricity rules and other statutory regulations currently in force in the country.

2.5 In case Indian standards are not available for any material, standards issued by IEC / BS / VDE / IEEE / NEMA or equivalent agency shall be applicable.
2.6 In case of any contradiction between various referred standards/ specifications/ datasheets and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- This specification.
- Codes and standards.

3.0 SITE CONDITIONS

Cables shall be suitable for installation in following conditions:

i. Above ground in open-air locations (trays / ducts) in tropical, humid and corrosive atmosphere prevalent in refineries/petrochemical plants with severe weathering and exposure to solar radiation.

ii. Directly buried in underground trenches, conduits with uncontrolled back-fill and possibility of flooding by water and chemicals.

iii. Unless otherwise specified, the design ambient air temperature of 45° C / ground temperature of 30° C.

iv. Cables shall be operating near electromagnetic radiations due to high voltage installation and other wireless equipments. Adequate screening shall be provided to make build the electromagnetic immunity.

4.0 TECHNICAL REQUIREMENTS - NON JELLY FILLED CABLES

4.1 Conductors

4.1.1 The size of conductor shall be as per job requirement.

4.1.2 The conductors shall consist of annealed, high conductivity solid copper wire, smoothly drawn, circular in cross-section, uniform in quality, free from defects and uniformly coated with pure tin and shall conform to Cl. 3.0 of DOT specification GR/WIR-06/03. For telecommunication cables conductor shall be 0.5 mm and for PA system conductor dia shall be 0.6 mm as minimum. For fire alarm cables size of conductor shall be chosen based on sum of the current drain of all field points in that circuit.

4.2 Insulation

4.2.1 The core insulation shall be with PVC compound applied over the conductor by extrusion.

4.2.2 PVC insulation, when used shall meet the following requirements:

<table>
<thead>
<tr>
<th>Conductor (Area)</th>
<th>Diameter</th>
<th>Type of Insulation</th>
<th>Thickness of Insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 0.63 mm (0.3mm²)</td>
<td>Type-2 of Table-3 as per IS-13176</td>
<td>As per Table-I of DOT Specs. GR/WIR-09/02</td>
<td></td>
</tr>
<tr>
<td>Above 0.63mm (Above 3.0 MM²)</td>
<td>Type-A as per IS-5831</td>
<td>Table-2 as per IS-1554 (Part-I)</td>
<td></td>
</tr>
</tbody>
</table>

4.2.3 The colours used for insulation shall conform as nearly as practicable to the standard colours as per 18-9938. The wire insulation shall have colours in accordance with Table-2 of DOT specification GR/WIR-06/03. The applied colour shall neither have deleterious effect on the electrical, mechanical or ageing properties of basic insulation nor shall get damaged by any friction etc.
4.2.4 For single pair cables, the colour shall be incorporated in the insulation.

4.2.5 For multi pair cables, cores shall have uniform pattern of continuous spiral (Pitch not exceeding 25mm) to facilitate easy identification. This may be done by the application of one or more coloured strips on a base colour or by direct extrusion.

4.2.6 Alternately, colouring may consist of concentric coloured rings or dots or dashes on the base colour. The coloured rings, dots or dashes shall have a width of not less than 1.0mm and shall be repeated along the length of the insulation at an interval not less than 15mm and not more than 25mm.

4.2.7 The dots or dashes shall be applied on diametrically opposite sides of the insulation, so that all colours are visible when the insulation is viewed from any side.

4.3 Twisting
The two insulated conductors of a pair shall be uniformly twisted with a suitable right hand lay, which shall not exceed 80mm.

4.4 Core Formation
The core formation shall conform to C1.6.0 of DOT specification no. GR/WIR-06/03.

4.5 Screen
4.5.1 Unless otherwise specified the cables used for fire alarm and detection shall be provided with overall screen. The screen shall be of aluminium tape with minimum thickness of 0.04mm. The overlap shall be minimum 3mm for cables up to 50 pair & minimum 6mm for cables above 50 Pair. The screen shall be backed by an outer protective layer of 0.13mm PVC tape or other non hygroscopic material lapped applied longitudinally or helically with overlap.

4.5.2 The cables shall be provided with a drain wire. Drain wire shall have a minimum cross-section of 0.5mm², shall be composed of multistrand bare tinned annealed copper conductor. The drain wire shall be in continuous contact with the aluminium side of the overall screen. The drain wire resistance including screen shall not exceed 30 ohm/km.

4.6 Ripcord
A non-metallic ripcord of suitable quality shall be laid longitudinally under the inner sheath & screen. The ripcord when pulled shall cut through the sheath and strip the core.

4.7 Inner Sheath
4.7.1 An extruded inner sheath of type ST1 PVC, as per IS-5831, with minimum thickness as per Table-4 of IS-1554 (Part-1) shall be applied over the laid up core, by extrusion to fit closely on it.

4.7.2 The inner sheath shall be as circular as possible. It shall be possible to remove the inner sheath without damage to the insulation.

4.7.3 When one or more layers of non-hygroscopic tape is helically applied over the laid up cores, as a binder, the thickness of such tape(s) shall not be construed as a part of the inner sheath.

4.8 Armour
4.8.1 The cables shall be provided with armouring, made of hot dip galvanised steel wire /strip over the inner sheath.
4.8.2 The armour shall be by means of 10.4mm thick round wires for cables with under armour diameter upto 13mm. For cables with an under armour diameter above 13mm, the armour shall either be of steel strip or round wire with thickness as per IS-1554 (Part-1).

4.9 Outer Sheath

4.9.1 The cables shall be provided with an extruded PVC sheath for external protection. The PVC shall be type ST1 PVC, as per IS-5831.

4.9.2 The other sheath shall be with oxygen index 29 at 27±2°C and possess flame retardant properties meeting the requirements of IS 10810 Part-62 category - AF. In addition, suitable chemicals shall be added to the PVC compound of the outer sheath to protect the cable against rodent and termite attack.

4.9.3 The thickness of outer sheath shall be as per IS-1554 (Part 1).

4.9.4 The outer sheath shall fit tightly on the armour and shall be applied in such a manner that no undue residual strain is left in the material.

4.9.5 The outer sheath shall be grey in colour except for cables to be used for fire alarm system where it shall be red.

4.9.6 Sequential marking of the length of the cable, in meters, shall be provided on the outer sheath at every one meter. The marking shall be legible and indelible by suitable method.

4.9.7 The overall diameter of the cables shall be strictly as per the values declared in the technical information furnished along with the bids, subject to a maximum tolerance of ±2 mm.

4.10 Cable Capacitance

4.10.1 The core to core capacitance of the cables shall not exceed 100nF/Km at 1KHz.

4.10.2 The core to screen capacitance for the screened cables shall not exceed 250nF/Km at 1KHz.

5.0 TECHNICAL REQUIREMENTS FOR JELLY FILLED CABLES

5.1 Jelly filled telecom cables shall in general conform to the requirements of DOT specification G/CUG-01/02, unless otherwise specified in this specification.

5.2 Conductors

5.2.1 The conductors shall consist of annealed, high conductivity solid copper wire, smoothly drawn, circular in cross-section, uniform in quality, free from defects and uniformly coated with pure tin and shall conform to cl. 3.0 of DOT specification G/CUG-01/02.

5.3 Insulation

5.3.1 Each conductor shall be insulated with insulating grade PE conforming to C1.4.0 of DOT specification G/CUG-01/02.

5.4 Twisting

The two insulated conductors of a pair shall be uniformly twisted with a suitable right hand lay, which shall not exceed 150mm.

5.5 Core Formation

The core formation shall conform to C1.6.0 of DOT specification G/CUG-01/02.
5.6 **Filling Compound**

5.6.1 The cable shall be filled with a suitable stable water resistant compound, which shall be compatible with the insulation, binders and tapes used in the cable.

5.6.2 It shall be homogeneous and uniformly mixed material containing an anti-oxidant.

5.6.3 The compound shall not obscure the identification of the colour of the insulation of the conductors.

5.6.4 It shall not contain dirt, metallic particles or other foreign matter.

5.6.5 The compound shall be readily removable from the insulated conductors by wiping.

5.6.6 It shall be free from any unpleasant odour and shall have no toxic or dermatic hazards.

5.6.7 The flash point of the compound shall not be less than 200°C.

5.6.8 The volume Resistivity measured at 100°C shall not be less than 1010 ohm·em.

5.6.9 The permittivity at 1 MHz tested as per ASTM 0-924 shall not be greater than 2.3 at 20°C.

5.7 **Core Wrapping**

At least one closed helical or longitudinal application of a non-hygroscopic and non-wicking polyester tape or tape of any other suitable material shall be provided over the cable core.

5.8 **Screen**

5.8.1 The cables shall be provided with overall screen. The screen shall be of aluminium tape with minimum thickness of 0.2mm. The overlap shall be minimum 3mm for cables having maximum diameter over inner sheath < 30mm & minimum 6mm for cables having maximum diameter over inner sheath ~ 30mm. The screen shall be coated with 0.05 mm nominal thickness polythene/copolymer on both sides. The thickness of the composite tape shall be 0.3mm±15%.

5.8.2 The aluminium tape shall be electrically continuous throughout the length of the cable.

5.9 **Inner Sheath**

5.9.1 The inner sheath shall be as circular as possible and free from pinholes and other defects. It shall be possible to remove the inner sheath without damage to the insulation.

5.9.2 The inner sheath shall be of polythene conforming to type 03C or H03C of BS 6234 and shall contain a suitable antioxidant system. The material shall be virgin as per ASTM 0-883 and meet the following requirements.

- **Density**: 0.910 to 0.940 g/100g for 03C and > 0.940 g/100g for H03C
- **Melt Flow index**: Maximum 1.0 g/10 minutes (190 °C, 2160 g load)

5.9.3 The thickness of inner sheath shall conform to Table - 6 of DOT specification no. G/CUG01/02.

5.9.4 The maximum diameter over inner sheath shall conform to Table - 7 of DOT specification no. G/CUG-O 1/02.

5.10 **Armour**
5.10.1 The cables shall be provided with bedding and armour over the inner sheath.

5.10.2 The bedding shall consist of two close helical lappings of polythene or polypropylene tape. Each tape shall be applied with a minimum of 5% overlap.

5.10.3 The armour shall be made of hot dip galvanised steel tape of thickness as per Table - 8 of DOT specification G/CUG-01/02.

5.11 Outer Sheath

5.11.1 The external protection shall consist of a polythene sheath conforming to the material specification defined in Clause 5.9 above.

5.11.2 The thickness of outer sheath shall conform to Table - 9 of DOT specification G/CUG-01/02.

5.11.3 The outer sheath shall be as circular as possible and free from pinholes and other defects. It shall be possible to remove the inner sheath without damage to the insulation.

5.11.4 The outer sheath shall be grey in colour except for cables to be used for fire alarm system where it shall be red.

5.11.5 The maximum diameter over outer sheath shall conform to Table - 7 of DOT specification G/CUG-01/02.

5.12 Cable Capacitance

The average mutual capacitance of the pairs measured at 800 to 1000Hz shall be 52 ± 3 nF/km.

However, the mutual capacitance of individual pairs shall be within the limits of 52 ±4.5 nF/km.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 The cables shall be tested and examined at the manufacturer's works. All the materials employed in the manufacture of the cable shall be subjected to examination, testing and approval by PDIL/Owner. Manufacturer shall furnish all necessary information concerning the supply to PDIL/Owner's inspectors. The inspector shall have free access to the manufacturer's works for the purpose of inspecting the process of manufacture in all its stages and he will have the power to reject any material, which appears to be of unsuitable description or of unsatisfactory quality.

6.2 The following acceptance tests shall be conducted on the completed jelly filled cables as per the test procedures given in DOT specification G/CUG-01/02 and this specification:

i. Measurement of diameter of conductor, over inner sheath & over outer sheath.

ii. Measurement of Thickness of insulation, inner sheath, screen, armour & outer sheath.


vi. Colour coding.

vii. Conductor continuity test.
viii. Mutual Capacitance test.
ix. Capacitance Unbalance test.
x. Cross talk test.
xi. Attenuation test.
xii. Insulation resistance test.
xiii. Dielectric strength test.
xiv. Drip test.
 xv. Armour Galvanisation Test.
 xvi. Conductor Annealing Test.
 xvii. Measurement of drum length.

6.3 The following tests shall be conducted on the completed non jelly filled cables as per the test procedures given in DOT specification GR/WIR-06/03 and this specification:

6.3.1 Acceptance tests:
i. Measurement of diameter of conductor, over inner sheath & over outer sheath.
ii. Measurement of Thickness of insulation, inner sheath, screen, armour & outer sheath.
iv. Colour coding.
v. Conductor continuity test.
vi. Mutual Capacitance test.
vii. Capacitance Unbalance test.
viii. Insulation resistance test.
ix. High Voltage test.
x. Armour Galvanisation Test.
 xi. Conductor Annealing Test.
 xii. Measurement of drum length.

6.3.2 Special Tests
The non jelly filled cables shall also be subjected to following special tests.
i. Oxygen Index test as per IS-1 0810 (Part 58).
ii. Flammability test on finished cable as per IS-10810 (part 61 & 62).

The special test shall be conducted on one sample from each lot. The sample will be selected by the inspector.

7.0 PACKING AND DESPATCH
7.1 Cables shall be despatched in non-returnable wooden drums of suitable barrel diameter, securely battened, with the take-off end fully protected against mechanical damage. The wood used for construction of the drum shall be properly seasoned, sound and free from defects. Wood preservatives shall be applied to the entire drum. Ferrous parts used shall be treated with a suitable rust preventive finish or coating to avoid rusting during transit and storage.

7.2 On the flange of the drum, necessary information such as project title, manufacturer's name, type, size, length of cable in meters, drum no., cable code, BIS certification mark, gross weight, 'Owner's particulars', 'P.O. numbers' etc., shall be printed. An arrow shall be printed on the drum with suitable instructions to show the direction of rotation of the drum.

7.3 Cables shall be supplied in drum lengths of 1000 meters, if not specified otherwise.

7.4 For non jelly filled cable, PVC / rubber end caps shall be supplied free of cost for each drum with a minimum of eight per thousand meter length. In addition, ends of the cables shall be properly sealed, with caps, to avoid ingress of moisture/water during transit and storage.

7.5 For jelly filled telephone cables, the ends of the cable shall be sealed by thermo shrinkable end caps of adequate wall thickness. Alternately ends may be sealed by enclosing them in rubber or PVC caps of wall thickness not less than 1.8mm. The caps shall be secured to the outer sheath with hose clips or ties or black adhesive tape or heat shrinkable sleeves.

7.6 The cables may be stored outdoors for long periods before installation. The packing shall be suitable for outdoor storage in areas with heavy rains / high ambient temperature, unless otherwise agreed.
TECHNICAL SPECIFICATION
CAPACITOR BANK & ASSOCIATED EQUIPMENT
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1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in packed condition of “Indoor type Shunt Capacitor Bank & Associated Equipment” required for system power factor improvement.

1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

1.3 The capacitor bank and associated equipment shall generally consist of the following.
   i) Basic Star connected capacitor bank
   ii) Basic capacitor unit with built in fuse
   iii) Discharge resistor
   iv) Series reactor
   v) Residual V. T. for mounting voltage unbalance
   vi) Set of Raychem make heat insulated sleeved of suitable voltage rating for bus bars.
   vii) Copper bus bar interconnecting the basic units.
   viii) Set of supporting insulators
   ix) Hot dip galvanised Steel stand/racks / cabinets of mounting capacitor units complete with interconnection insulator etc.
   x) Door limit switch
   xi) Control panel for automatic operation
   xii) Any other equipment not specified, but required for safe & proper operation of the system.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture & testing of the equipment covered by this specification shall comply with the latest issues of following Indian standards, unless otherwise specified.

<table>
<thead>
<tr>
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<tr>
<td>IS: 13925-1,2,3 / IEC 60871</td>
<td>Shunt Capacitor for power system</td>
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<tr>
<td>IS/IEC:60947</td>
<td>Switch gear and control-gear for voltage up to &amp; including 1000V &amp; 1200V DC</td>
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<td>IS 4759</td>
<td>Hot-dip zinc coatings on structural steels and other allied products.</td>
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<tr>
<td>IS 60270</td>
<td>High Voltage test technique-Partial Discharge measurements</td>
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<tr>
<td>IS 8084</td>
<td>Interconnecting Bus bars for AC voltage above 1 kV up to and including 36 kV.</td>
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2.2 The design & operation features of equipment shall also comply with provision of the latest issue of the Indian Electricity Rules & other relevant statutory acts & regulation. The supplier shall, wherever, necessary, make suitable modification in the equipment to comply with the above.

2.3 Wherever, any requirement laid down in this standard differs, from that in Indian standard specification, the requirement specified herein shall prevail. Equipment complying with equivalent IEC standards shall also be acceptable.

3.0 SERVICE CODITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy - Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy - Electrical.

4.0 OPERATING REQUIREMENTS

4.1 The capacitor bank and associated equipment shall be suitable for operating at the specified rating continuously with the specified voltage and frequency variation under the ambient condition without exceeding the permissible temperature rise and without any detrimental effect on any part of equipment.

4.2 The capacitor bank and associated equipment shall be suitable for parallel switching and withstand the thermal and dynamic stresses caused by transient during switching operations.

5.0 GENERAL DESIGN FEATURES

5.1 Capacitor Unit

5.1.1 The capacitor bank / sub bank shall comprise of appropriate number of basic single phase units & which shall be connected in star formation to obtain rated KVAR at rated voltage.

5.1.2 Each unit shall have required number of capacitor elements housed in hermetically sealed, leak proof, sheet steel container. The container shall be provided with suitable brackets, supporting insulators, terminal & bushing for external connections.

5.1.3 Each element of basic units has its own built in fuse which shall isolate the faulty element automatically without affecting the healthy elements.

5.1.4 The capacitor units shall have overload capacity as per IS 13925. The capacitor bank shall be suitable for continuous operation at 110% of rated RMS voltage and at 130% of rated RMS current.

5.1.5 Capacitor units shall be all high grade All Polypropylene type with non-PCB base, bio degradable, non-toxic impregnant. The capacitors offered shall be built from best material and shall develop minimum losses. Capacitor bank losses shall be given at
45°C. Capacitor shall be compact in size, metal enclosed and hermetically sealed. Internal silver wire fuses shall be provided for protection of each capacitor element.

5.1.6 The Capacitor bank and associated equipments shall be suitable for parallel switching and withstand the thermal and dynamic stresses by transient during switching operation.

5.1.7 All the fasteners and bolts shall be hot dip galvanized or zinc passivated.

5.1.8 Capacitors shall be provided with Overpressure protection as necessary for safety. Overpressure switches shall be fitted to the capacitor units and connected to trip the capacitor bank.

5.1.9 Each unit shall have required number of capacitor elements housed in sealed, leak proof, sheet steel container. The container shall be provided with suitable mounting brackets, supporting insulators, terminal & bushing for external connections.

5.1.10 The indoor capacitor bank units shall be installed in metallic housing with minimum IP-43 protection.

5.1.11 Each capacitor unit shall be mounted so that it can be easily removed from the racks and replaced without removing other units, de-assembling any part of the rack.

5.1.12 The outside of the capacitor units and other structures should have smooth and tidy look and should be coated with weather-proof, corrosion resistant epoxy paint of light gray shade, shade no. 631 of IS 5. The structure shall be suitably GI coated. Minimum coating shall not less than 600 micron / sq meters.

5.1.13 Each element of basic units has its own built in fuse which shall isolate the faulty element automatically without affecting the healthy elements. In case of one element failure, harmful over voltage shall not be generated across remaining elements and shall not make appreciable change in the operation of capacitor bank. An operation of a single fuse element does not cause cascaded fuse blowing. Permissible over voltages and surges do not cause fuse blowing.

5.1.14 The operating & design temperature category of the capacitor unit shall be +5°C as per IS-13925 part-1. Only 5°C temperature rise is permissible above the design temperature of 45°C. So maximum temperature in any case shall not exceed 50°C (i.e. 45°C (design) +5°C (temperature rise)).

5.1.15 The capacitor shall have low value of loss which shall not exceed 0.2 watt per KVAR. The loss value of discharge device/resistor and capacitor unit shall be indicated. The tan delta characteristics of the capacitor units shall be furnished. The losses in watts for each capacitor unit including losses in fuses and discharge resistors forming integral part of the capacitors along with losses for series reactor shall be guaranteed. If these figures of capacitor losses exceed 0.2 watt per KVAR, the capacitors will be liable for rejection. However owner reserve the right to use the faulty capacitor unit till the same are replaced/rectified. The loss temperature characteristics, capacity temperature characteristics and insulation resistance temperature characteristics shall also be furnished.

5.1.16 The bidder shall furnish calculations for rise in voltage in other units in the event of failure of element(s) of a capacitor unit. The maximum rise in voltage shall not be more than 10% of rated voltage even if the entire capacitor unit failed/short circuited and relevant calculations in support of this shall also be furnished.

5.1.17 The bidder shall furnish calculation of voltage drop at rated capacitor unit per phase & losses of the reactor.

5.1.18 For both capacitor and reactor, mounting arrangement and minimum clearance required from live parts shall be indicated clearly and shall be as per Indian Electricity Act/BS162 & IS-13925-Part2 / IEC-60871-2.
5.2 Discharge Device

5.2.1 A suitable discharge resistor of adequate rating shall be permanently connected across the terminals inside the container to discharge the residual voltage to 50V or less within 1 minute for capacitor rated upto 650V and within 5 minute for capacitor rated above 650V.

5.3 PROTECTIVE FUSES

5.3.1 An internal current limiting fuse with high rupturing capacity conforming to relevant IS/IEC and the specific requirements mentioned in IS13925-Part-3/IEC 60871- 3, shall be provided. The characteristics of the fuse shall be such that it shall isolate the faulty unit only, and protect it against mechanical destruction due to internal failure. The fuses shall not melt or deteriorate when subjected to inrush currents which occur during the life of the bank.

5.3.2 The fuses shall not make any healthy capacitor element out of circuit, either in course of isolating the faulty element or due to any external fault.

5.3.3 The selection of fuse to be done in such a manner that characteristic of fuse shall match suitably with over-current withstand characteristic of associated capacitor unit.

5.3.4 The fuses shall be of adequate thermal capacity to cater for the increased heating which may occur due to harmonics and capacitor current fluctuations.

5.3.5 The number of externally connected capacitors and the available short-circuit current of the supply system should not affect the current-limiting of internal fuses.

5.3.6 It may be noted that provided internal fuses do not lead to case rupture.

5.4 Series Reactor

5.4.1 A suitable series reactor conforming to IS: 5553 to limit the inrush current and suppress the harmonics shall also be provided whenever required.

5.4.2 The reactor shall be copper wound, non-magnetically shielded, oil immersed, natural cooled, sealed type and shall be provided with following fittings.

i) Oil sampling cum drain valves.

ii) Filter valves with plugs.

iii) Buchholz relay with shut off valves, air release device & alarm and trip contact.

iv) Oil temperature indicator with minimum marking.

v) Oil level indicator with minimum marking.

vi) Oil conservator complete with drain plugs and oil filling hole with cover.

vii) Silica gel breather with oil seal & connecting pipes.

viii) Explosion vent.

ix) Bi-directional rollers.

x) Thermometer pocket.

xi) Radiator with isolating valves.

xii) Marshalling box.

xiii) Rating plate, wiring diagram plate & terminal marking plate.

xiv) Lifting lugs.

xv) Earthing terminals.

xvi) Air release device.

xvii) Cable termination arrangement for incoming & outgoing device.
5.4.3 Dry type/ Oil filled reactor shall only be offered. Such reactors shall be class F/H insulated.

5.4.4 The reactor shall have linear volt ampere characteristics upto 150% of rated capacitor current.

5.5 Residual voltage transformer

5.5.1 3 phase dry type residual voltage transformer of adequate capacity to facilitate neutral unbalance protection and rapid discharging of capacitor shall be provided.

5.5.2 The primary winding of voltage transformer shall be star connected while the secondary winding shall be in open delta for connection to neutral phase displacement relay.

5.5.3 The accuracy class shall be 3P for protection & 1 for metering.

5.5.4 RVT shall have primary and secondary windings made of copper.

5.6 Door limit switch

5.6.1 A door limit switch suitable for mounting on the door frame of the capacitor room shall be provided for each bank. This door limit switch shall be used to trip the power supply to capacitors with initiation of opening action of the door of the capacitor room.

5.6.2 A door limit switch shall be totally enclosed in the aluminium / cast iron housing, fully oil, water & dust tight and shall conform to utilization category AC 11 / DC 11 as per IS: 6875. This shall be fast actuation type provided with 6 sets of 1 NO & 1 NC contacts rated for 5 amps at 415V AC and 1A at 220V DC.

5.7 Capacitor control panel

5.7.1 Capacitor control panel for control, protection and automatic switching operation of MV capacitor bank shall be provided.

5.7.2 Capacitor control panel shall be of dust, damp & vermin proof construction having enclosure class IP-51 as per IS/IEC:60947.

5.7.3 The enclosure shall be fabricated out of the cold rolled sheet steel having minimum thickness of 2 mm. The doors shall have concealed hinges & provided with neoprene gaskets.

5.7.4 The panel shall be liberally designed. All the components shall be accessible from the front. It shall be possible to attend any component without the necessary removing adjacent ones. All the relays, meters, push buttons including lamps etc. shall be flush mounted. The mounting height of components requiring operation & observation shall not be lower than 300 mm & higher than 1800 mm.

5.7.5 The capacitor control panel shall control the capacitor bank which in turn shall have a number of sub banks for easy of control & to maintain the desired power factor under varying load conditions.

The owner shall arrange C.T supply to sense the power factor. Necessary C.T., selector switch, power factor meter and power factor correction relay shall be provided in the control panel. In addition, the control panel shall have Photo manual selector switch and P.F. raise lower push buttons for manual operation. These common features shall be located near the incoming unit.

5.7.6 Each control shall be provided with TPN switch, voltmeter with selector switch, Ammeter with selector switch and other auxiliaries, as required to receive the incoming power.
5.7.7 No. of outgoing feeders for the control panel shall be decided as per the no. of sub banks to be controlled by it. Each feeder shall be provided with TP switch, fuses, contacts, "ON" & "OFF" indication lamps and other auxiliaries as required.

5.7.8 Required no. and size of heavy duty double compression type Aluminium cable glands suitable for incoming and outgoing power and control cables shall be mounted on removal gland plate provided at a minimum height of 75 mm from the bottom of the panel. Crimping type Aluminium and copper lugs for aluminium and for copper cable respectively shall be provided for termination of cables.

5.7.9 The control panel shall be complete with its base channels, foundation bolt etc.

5.7.10 A continuous earth bus of aluminium, running along the entire length of the lower part of the control panel shall be provided with lugs at two ends for connection with external earth grid. The minimum size of earth bus shall be 150 sq. mm.

5.7.11 Components Details

5.7.11.1 The switches shall be of capacitor duty type rated for 1.5 times the rated capacitor current with a minimum rating of 25 A and shall conform to IS/IEC:60947.

5.7.11.2 The fuses shall be of non-deteriorating HRC link type and suitably rated for capacitor switching. These shall conform to IS: 13703.

5.7.11.3 All contactors shall be of capacitor duty type rated for 50% higher than rated capacitor current & shall conform to IS/IEC:60947. Control supply voltage shall be 240V single phase AC unless otherwise stated. One set of NO & NC potential free contacts shall be made available as spare.

5.7.11.4 Ammeter, Voltmeter & power factor meter shall be of accuracy class 1.5 as per IS: 1248 of minimum 96 sq.mm size & shall have 0-2400 scale.

5.7.11.5 The push buttons & selector switches shall conform to utilisation category AC11/ DC11 as per IS: 6875. Contacts shall be rated for 5A at 415V AC and 1A at 220V DC. The push button shall be of momentary contact spring loaded type with a set of 1 NO & 1 NC contacts. The selector switches shall be stay put type and provided with oval shaped handles.

5.7.11.6 The signal lamps shall be LED type. Colour of lamp shall be “Red” for “ON” & “Green” for “OFF” signals.

5.7.11.7 Terminal blocks shall be pressure clamp type up to 35 sq. mm. cable and bolted lugs type for higher sizes of cables. The minimum current rating of terminal block shall be 16A. 20% extra terminals shall be provided in the terminal block.

5.8 BUS BARS

5.8.1 All bus bars interconnecting the basic units shall be of copper and shall be fully insulated by using Raychem make heat shrinkable sleeves. All bus bar joints and tap-off connections shall be provided with removable FRP shrouds. The sleeves shall be rated to withstand the system Line-to-Line voltage for 1 minute.

5.8.2 The minimum clearances shall be as per relevant standards suitable for the nominal voltage of capacitor banks.

5.9 External cable termination

5.9.1 Each capacitor bank / sub bank shall be provided with proper termination arrangement where terminal connection from all the three phases shall be brought for connection with external cable. The termination arrangement shall include cable glands, cable lugs, termination kits, supporting arrangements etc. complete in all respect.
5.9.2 A cable box for termination of control cables shall be provided on the RVT. The cable boxes shall be provided with adequately sized cable entries and suitable double compression cable glands made of stainless steel. Tinned copper lugs shall be provided for the connection of all cable cores.

5.10 Interlocks
All necessary interlocks to ensure correct & safe operation of capacitor banks shall also be provided.

5.11 Earthing
Each basic capacitor unit shall be connected to the earth strip provided on the steel racks which in turn shall be connected to the main earth grid through two nos. suitable earth terminals provided on the racks.

6.0 PROTECTIVE SCHEME (PROVIDED BY PURCHASER)
6.1 The vendor shall confirm the adequacy of these protective devices and also suggest the setting and any other additional protective devices required.

7.0 ACCESSORIES
The supply shall include the following accessories.

7.1 Control panel space heater
The control panel shall be provided with a thermostatically controlled space heater, rated for 240V, 50Hz & controlled through double pole miniature circuit breaker.

7.2 Name plate
7.2.1 All the equipment shall be provided with name plates containing all the information’s as per relevant standard.
7.2.2 All control switches, push buttons, lamps etc. shall have functional identification labels.
7.2.3 Name plate of capacitor control panel shall be of black prespex with white engraving and of minimum 3 mm thickness while those on other equipment shall be of stainless steel.

7.3 WARNING PLATES
7.3.1 Warning plates shall be provided on the door and inside of the equipment, comprising following information:
    CAUTION: HIGH VOLTAGE CAPACITORS.
    AT BLOWN FUSES, CHARGES MAY REMAIN
7.3.2 The warning plates shall be UV resistant engraved plastic.

7.4 Steel racks
7.4.1 Sheet steel racks shall be provided to house the capacitor units, residual P. T. etc. in tier formation.
7.4.2 The racks shall be suitable for assembly at site. The racks & hardware used for assembly shall be hot dip galvanized.
7.4.3 The rack shall be complete with rack insulators, foundation bolts or any other hardware etc. for assembly into complete bank.
7.4.4 Complete assembly of capacitor bank shall be mounted on a pedestal GI frame, which shall be 300 mm high.
7.4.5 Any other accessories required but not specified, shall be supplied to make the capacitor installation complete in all respect and ensure safe & proper operation.

8.0 PAINTING

8.1 The sheet steel enclosure after degreasing, pickling in acid, cold rinsing, phosphatising passivating etc. shall be painted with two coat of anti-rust paints followed by two coats anti corrosive paints.

8.2 Epoxy based paint shall be used.

8.3 All paint shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handing.

8.4 Unless otherwise specified, the finishing shade shall be light gray shade no. 631 as per IS: 5.

9.0 TESTS AND INSPECTION

9.1 All capacitor banks and control panel shall be subjected to routine tests as per IS: 2834 and its associated equipment as per relevant standards.

9.2 Additional tests, wherever specified, shall be carried out.

9.3 All the above tests shall be carried out in presence of purchaser’s representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works & site inspection.

9.4 These inspections shall, however, not absolve the vendor from his responsibility for making good any defect which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have following description written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance
Item wise unit prices of spare parts shall be quoted.

11.2 Commissioning Spares
Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.
11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipments.

12.0 PACKING

12.1 All the equipment shall be properly packed before despatch to avoid damage during transport, storage & handling.

12.2 The packing box shall contain a copy of the installation, operation & maintenance manual.

12.3 A sign to indicate the upright position on the position of the package to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
## ANNEXURE - I

### DOCUMENTATION FOR CAPACITOR BANK & ASSOCIATED EQUIPMENT

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Documents Required (Y / N)</th>
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<td>Technical Particulars</td>
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<td>3.</td>
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<td>N</td>
</tr>
<tr>
<td></td>
<td>- Capacitor bank</td>
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<td></td>
<td>- Reactor</td>
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<td></td>
<td>- Control panel</td>
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<td>Foundation plan indicating certified dimensions floor opening, weight, clearance etc.</td>
<td>N</td>
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<tr>
<td></td>
<td>- Capacitor bank</td>
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<td>- Reactor</td>
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<td></td>
<td>- Control panel</td>
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<td>5.</td>
<td>Schematic &amp; wiring diagram</td>
<td>N</td>
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<td>6.</td>
<td>Descriptive literature of Various equipment</td>
<td>N</td>
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<td>7.</td>
<td>Installation, operation &amp; maintenance manual</td>
<td>N</td>
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<td>8.</td>
<td>Guarantee certificate</td>
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<td>9.</td>
<td>Test certificate</td>
<td>N</td>
</tr>
<tr>
<td>10.</td>
<td>Spare parts list with identification marks</td>
<td>N</td>
</tr>
</tbody>
</table>

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
TECHNICAL SPECIFICATION
CATHODIC PROTECTION POWER SUPPLY MODULE (CPPSM)
<table>
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<th>SECTION NUMBER</th>
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1.0 SCOPE

This specification covers the requirements for the design, manufacture and testing of Cathodic Protection Power Supply Module (CPPSM) working on controlled switch mode principle intended to supply power to cathodic protection system.

2.0 CODES AND STANDARDS

2.1 The system design, performance and materials to be supplied shall conform to the requirements of the latest revision of following standards:

- IS: 1248 (Parts-I, 2, 8 & 9) Direct acting indicating analogue electrical measuring instruments and accessories.
- IS: 3700 (Parts-I to 11) Essential rating and characteristics of semiconductor devices.
- IS: 3715 (Parts-I to 4) Letter symbols for semiconductor devices.
- IS: 4411 Code of designation of semiconductor devices.
- IS: 6619 Safety code for semiconductor rectifier equipment.
- IS: 7204 (Parts-I to 4) Stabilised power supplies DC output.
- IS: 12021 (Parts-I to 4) Control transformers for switchgear and control gear for voltages not exceeding 1000 V AC.
- IS: 13703 (Parts-I to 4) Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC.
- IS/IEC:60947 Low voltage switchgear and control gear.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standards/ specifications/ and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- This specification.
- Codes and standards.

3.0 SITE CONDITION

The CPPSM shall be suitable for installation in non air-conditioned room with restricted ventilation or in outdoor kiosk in locations having generally corrosive, warm, humid and dusty atmosphere. Service conditions shall be as per actual site conditions. If not specifically mentioned therein, a design ambient temperature of 45°C and an altitude not exceeding 1000 m above mean sea level shall be considered.

4.0 GENERAL REQUIREMENTS

The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.
4.1 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.

4.2 Vendor shall give a notice of at least one year to the end user of equipment and owner before phasing out the product/spares to enable the end user for placement of order for spares and services.

5.0 TECHNICAL REQUIREMENTS

5.1 Fabrication and General Details

CPPSM shall be housed in sheet steel enclosure. The front, rear walls and doors shall be made by using minimum 2 mm thick sheet steel and side walls shall be made of minimum 1.6 mm thick sheet steel. Wherever required, suitable stiffeners shall be provided. The Unit shall be freestanding type. Hinged doors "Shall be provided at the front and back as required. The unit shall be natural cooled type. Louvered openings with wire mesh for natural ventilation may be provided. Degree of protection for the panel shall be minimum IP-41. The CPPSM panel shall, preferably, not need rear access for operation, maintenance and shall be suitable for mounting flushed to the wall.

5.1.2 Suitable hooks shall be provided for lifting the panel. These hooks when removed shall not leave any hole in the panel or imperfection in the paint finish.

5.1.3 All instruments shall be panel mounted type and back connected. All fuses shall be provided inside the panel and shall be of link type. 660 V grade PVC insulated BIS approved wires with stranded copper conductor of size minimum 2.5 mm2 shall be used for power and auxiliary wiring. Control wiring for electronic circuits shall be through flat ribbon cable or through copper wire of minimum 0.5 mm diameter. All wirings shall be ferruled with PVC ferrules at both ends for ease of identification. Clamp type terminals suitable for termination up to 10 mm conductor shall be provided for all control cable connection. Suitable power terminals shall be provided for power cables. Minimum 20% spare terminals shall be provided. The terminal blocks shall be mounted minimum 300 mm above the gland plate.

5.1.4 All live parts shall be properly shrouded. This shall ensure complete safety to personnel intending routine maintenance by opening the panel doors.

5.1.5 CPPSM shall be suitable for bottom cable entry unless otherwise specified and shall be supplied complete with crimping type tinned copper lugs and cable glands. Cable glands shall be of rolled aluminium single compression type for indoor installations and double compression type for outdoor installations. The space in the terminal chamber shall be adequate for termination of required number and sizes of cables.

5.1.6 The CPPSM shall be field proven. The design, internal component layout and rating of component shall ensure high MTBF and low MTTR. Prototype equipment shall not be acceptable. Layout of panel components shall enable easy access to the components for maintenance.

5.1.7 All the control equipment like switches, push buttons, potentiometers etc. shall be located at a convenient height of minimum 300 mm and maximum 1800 mm from the bottom of the panel.

5.1.8 The printed circuit boards (PCBs) shall be of copper clad glass epoxy laminate. PCB tracks shall be tinned and solder masked. The PCB shall be coated with suitable lacquer to make it immune to dust, moisture and fungal growth. Where plug in type of PCBs are used gold plated male-female connectors shall be used for the purpose.
5.1.9 If required the panel shall be provided with space heater to prevent moisture condensation. The space heaters shall be located at the bottom of the panel and shall be provided with a manually operated switch and HRC fuse. The space heater shall have porcelain-insulated connectors. Where space heater is not provided, the electronic PCBs/components and other control devices shall be made immune to moisture condensation.

5.1.10 Panel shall be provided with integral base frame channel. The integral base frame of panel shall be suitable for directly bolting with the help of foundation bolts and shall also be suitable for tack welding to purchaser's insert plate/flat/channel embedded in the floor. Amply dimensioned oblong holes shall be provided at the bottom of the panel for its bolting to the embedded insert plate/channel.

5.1.11 An earth bus bar of minimum (25 x 3) mm² copper or equivalent aluminium shall be provided throughout the length of the panel. Provision shall be made for connecting this earth bus at two ends with the plant earth grid by means of (40 x5) mm² GI flat. All non-current carrying metallic parts of the panel and mounted equipment shall be connected to the panel earth bus. All doors and movable parts shall be connected to the earth bus by flexible copper cables.

5.1.12 All panel mounted equipments (e.g. lamps, push buttons, switches, meters, PCBs, etc.) shall be provided with suitable nameplates. Nameplates shall be engraved out of 3-ply (black-white-black) lamicoid sheets or anodised aluminium. Back-engraved perspex sheet nameplates may also be acceptable. Engraving shall be done with groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable. Nameplates shall be fastened by screws and not by adhesive. Labels shall be provided for every component on the cards, connecting wires as well as for the terminals in the terminal strip inside the panel.

5.1.13 Where specified, the CPPSM shall be housed in an outdoor kiosk. The kiosk shall be made of sheet steel of minimum 3 mm thick and epoxy painted on both internal and external surfaces. Hinged lockable doors shall be provided at the front and back. Acrylic transparent glass window shall be provided on the front door of the kiosk so that the meters, indications and positions of the control switches on the CPPSM can be seen without opening the door of the kiosk. The kiosk shall be suitable for outdoor mounting and shall give proper protection to the CPPSM against rain, other harsh weather conditions. Necessary ventilation arrangement with louvers and wire mesh shall be provided for proper operation of the CPPSM. The cable entry to the kiosk shall be from bottom through cable glands. Suitable canopy shall be provided on the top of the kiosk.

5.1.14 **Painting**

All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt.

Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The undersurface shall be made free from all imperfections before undertaking the finishing coat.

After preparation of the under surface, the panel shall be spray painted with two coats of final paint or shall be powder coated. Colour shade of final paint shall be approved by the purchaser before final painting is started. The finished panels shall be dried in stowing ovens in dust free atmosphere. Panel finish shall be free from imperfections like pin holes, orange peels, run off paint, etc.
All unpainted steel parts shall be cadmium plated or suitably treated to prevent corrosion. If these parts are moving elements, then they shall be greased.

6.0 EQUIPMENT DESCRIPTION

The CPPSM shall be complete with following main sections:
- Input controls.
- Power converter and filters.
- Output protections
- System controls
- Current interrupter
- Control, indication and metering

6.1 Input Controls

6.1.1 A moulded case circuit breaker with thermal over load and short circuit release (rated for the input power supply short circuit current) shall be provided at the input for power supply control.

6.2 Power Converter and Filters

6.2.1 The CPPSM shall convert and control the input DC power supply voltage/current through switching power semiconductor devices (Thyristor/power transistor/power MOSFET, etc.). The variation in the output voltage/current shall be achieved through control of duty cycle of conduction of the switching power semiconductor devices. The current and voltage ratings of the power semiconductor devices shall be at least two times the maximum device current and min. two times the maximum voltage coming across it respectively. The voltage rating of the power semi-conductor devices shall be co-coordinated with the breakdown voltage of lightning arrester provided at the output so that the power semiconductor devices are protected from any voltage surge coming from the pipeline. Shunt zeners / MOV shall be provided across the power semiconductor devices for protection. The power semiconductor devices shall have humidity/moisture resistant finish and mounted in sufficiently sized heat sink designed to provide adequate cooling under worst conditions of operation. The power semiconductor devices shall have adequate protection against high dv/dt and di/dt.

6.2.2 Where specified, the converter shall electrically isolate the input power to CPPSM from its output so that the grounding of the positive output of the CPPSM through anode ground bed shall not affect the grounding system of the input power supply. Alternatively, a separate DC to DC converter having electrical isolation between input and output power supply shall be provided at the input of the CPPSM.

6.2.3 The power semiconductor devices shall be protected by semiconductor fuses or the system shall have instantaneous short circuit-current limit feature to protect the devices against output short circuits. An adjustable output over current limit feature shall be provided.

6.2.4 Filter shall be provided in the input power supply circuit to minimise the AC injected into the DC input power supply system.

6.2.5 Adequate filtering shall be provided on the DC output of the converter to limit the ripple content in the output to less than 5% at rated output.

6.2.6 The converter system shall be of natural air cooled type.
6.2.7 For CPPSMs with multiple output circuits, each output circuit shall have independent output converter and output filters.

6.3 Output Protections

Two pole moulded case circuit breaker or miniature circuit breaker rated for the DC output current, short circuit current and having thermal over load, short circuit release shall be provided in the output. A lightning arrester rated for minimum 10KA impulse current discharge capacity and rated voltage & max. spark over voltage rating suitable to protect the CPPSM components against lightning and switching surges shall be provided at the output. For CPPSMs with multiple output circuits, each output circuit shall have independent protections.

6.4 System Controls

6.4.1 The CPPSM shall have two distinct modes of operation (independent for each output circuit) as below:

a) Constant Voltage - Constant Current Mode (CVCC)

In this mode the output voltage (Vos) of CPPSM shall be continuously adjustable from 0.5V DC to the rated output voltage. Current limit feature shall be provided in this mode of operation. The current limit (ilos) shall be continuously adjustable from zero to rated output current.

For constant voltage mode of operation the output current limit shall be set at maximum and output voltage setting shall be varied. Irrespective of output current demand the chosen value of the output voltage shall be maintained by the control system till the current limit is reached. After that the output current limit shall be maintained and output voltage shall decrease to keep the current constant.

For constant current mode of operation the output voltage shall be set at maximum and output current shall be varied through varying the setting of output current limit. Irrespective of output voltage requirement the control system shall maintain the output current to the set current limit value till the voltage limit is reached. After that the output voltage limit shall be maintained and output current shall decrease to keep the voltage constant.

b) Auto PSP Mode

In this mode of operation the output of the CPPSM shall operate in an external closed loop with pipe-to-soil potential (PSP) in feedback loop. The CPPSM control shall adjust the output voltage such that the PSP as measured by reference cell always remains equal to the set potential on the unit. The set potential (Vps) shall have high long time stability and minimum temperature drift. The set potential shall be continuously adjustable over the range as required. An adjustable over current limit shall be provided to limit the maximum output current.

The unit shall be designed to operate with the number of reference cells connected to it (to be provided by others). In case of more than one reference cell being specified, CPPSM shall have feature to automatically select the reference cell having less negative potential than the others and use the same for auto control of the unit (e.g. (-) 0.8 V is less negative than (-) 0.9 V). Adequate hysteresis shall be provided in selecting the less negative potential reference cell, to avoid hunting between the reference cells at change over conditions.

In case of open circuit or short circuit of the reference cell or potential being less negative than a minimum set potential (Vrs), for the controlling reference cell, the
unit shall sense these conditions as reference cell failure and shall automatically switch over to the other healthy reference cell for control. Should fault occur in all the reference cells, the output voltage or current of the CPPSM shall adjust automatically to a preset value (Vas/las), which shall be adjustable.

In both CVCC and auto PSP modes of operation the electronic over current limit shall be fast enough to protect the active devices of the unit and fast enough to act before tripping of MCCB/MCB or blowing of fuse.

6.4.2 The unit shall continuously monitor the PSP and necessary annunciation shall be provided in case of PSP either exceeding the specified maximum limit (Vpm) or remaining lower than the specified minimum limit (Vpn).

6.4.3 The output voltage regulation for no load to full load variation with input voltage variation from maximum to minimum shall not be more than 2.5% of rated voltage throughout the range of output voltage and over the specified ambient temperature variation, in CVCC-constant voltage mode of operation. In auto PSP mode the closed loop PSP regulation for no load to full load variation with input voltage variation from maximum to minimum shall be within 20mV throughout the PSP setting range specified.

In CVCC-constant current mode of operation, the current regulation for minimum to maximum output voltage and minimum to maximum variation in input voltage shall not be more than 2.5% throughout the range of output current.

6.4.4 The output of the unit shall be ungrounded and shall allow grounding of positive terminal of the output through the anode ground bed.

6.4.5 For CPPSMs with multiple output circuits, each output circuit shall have independent control system.

6.5 Current Interrupter

6.5.1 If required a current interrupter for CPPSM output current interruption shall be provided.

6.5.2 The current interrupter shall have an output contactor with current rating minimum 125% of the output current rating of the CPPSM and a digital timer to operate it.

6.5.3 The timer shall have ‘ON’ and ‘OFF’ timings. When the timer is turned on the ‘ON’ timing shall start and shall close the output contactor till the end of the ‘ON’ timing. At the end of the ‘ON’ timing the ‘OFF’ timing shall start and keep the contactor open till the end of the ‘OFF’ timing. At the end of the ‘OFF’ timing the ‘ON’ timing shall start again. This process of ‘ON’ and ‘OFF’ timing shall continue.

6.5.4 The ‘ON’ and ‘OFF’ timings of the timer shall be settable by separate 2 digit thumbwheel switches, each settable from 1 to 99 seconds. The timing error of the timer shall be less than 5 parts per million. In case of microprocessor based system keypad with display may be provided in place of thumbwheel switches.

6.5.5 Whenever the timer is switched on it shall always start with ON ‘timing’. A timer-reset push button shall be provided. On pressing this pushbutton during operation of the timer, the timer shall get reset and upon release of the button, the timer shall restart with ‘ON’ timing.

6.5.6 The power required for operation of the timer and contactor shall be derived from the main power supply to the CPPSM.
6.5.7 The following controls and indications shall be provided for current interrupter. The controls shall be housed in a lockable cover, so that normally they are not accessible. The indications shall be mounted on the door.

a) Controls
   - Timer power 'ON' / 'OFF'
   - Timer reset
   - Thumb wheel switch for 'ON' timing
   - Thumb wheel switch for 'OFF' timing
   In case of microprocessor based system, keypad with display may be provided in place of thumbwheel switches.

b) Indications (LED)
   - Timer power 'ON'
   - 'ON' timing
   - 'OFF' timing

6.5.8 The output contact of the current interrupter contactor shall be wired in the positive DC output of the CPPSM. A link shall be provided for shorting these terminals whenever the current interrupter is not in use.

6.5.9 If required the current interrupter shall be an independent unit of portable type. The interrupter unit shall have terminals for input power supply and terminals of the contactor in the timer output. The input power supply and the rating of the timer output contactor shall be as required.

6.5.10 Where the current interrupter is not specified with CPPSM or is specified as portable type external to the CPPSM, then the CPPSM shall have provision for connection of input power supply terminals and output contacts of external current interrupter for current interruption test. A link shall be provided for shorting the output terminals provided in CPPSM for current interruption, whenever the current interrupter is not connected.

6.5.11 For CPPSMs with multiple output circuits, each output circuit shall have independent current interrupter.

6.6 Controls, Indication and Metering

6.6.1 Following controls shall be provided on CPPSM front door.

a) ON/OFF control for input through MCCB.

b) ON /OFF control for output through MCCB/MB.

c) Auto/CVCC mode selector switch.

d) Potentiometers for Vos, Vps and los settings.

e) Selector switch for selecting indication of PSP set and PSP actual for all the reference cells.

6.6.2 Following controls shall be provided inside the module at user accessible common location:

a) Potentiometer for Vrs, Vpm, Vpn and Vas/ias settings.

b) Controls for current interrupter:
   - Timer power 'ON' / 'OFF'
   - Timer reset
- Thumb wheel switch for 'ON' timing
- Thumb wheel switch for 'OFF' timing

6.6.3 CPPSM shall have following indicating lights (lamps or minimum 5 mm dia LEDs):

a) CPPSM ON/OFF
b) Unit in auto/CVCC (2 lamps)
c) Reference cell controlling the closed loop control of the CPPSM (number of lamps same as number of reference cells).
d) Reference cell faulty (number of lamps same as number of reference cells).
e) Pipeline over protected.
f) Pipeline under protected
g) Indications for current interrupter:
   - Timer power 'ON'
   - 'ON' timing
   - 'OFF' timing

It shall be possible to switch-off all the indication lamps by a single switch. In case of LED indication lights this facility may not be provided.

6.6.4 Following meters having min cl. 1.5 accuracy shall be provided on the CPPSM:

a) Digital meter for output voltage
b) Digital meter for output current
c) Digital voltmeter to measure PSP set (Vps) and PSP actual for all the reference cells. The meter shall have range from (-) 4 V to 0 V and shall have cl. 0.5 accuracy.
e) Digital meters for measuring Vrs, Vpm, Vpn and Vas/las settings.
f) Meters for input voltage and current

It shall be possible to switch-off all the digital meters preferably by a single switch.

6.6.5 If specified, CPPSM shall incorporate provision for remote monitoring of the unit through SCADA system as below:

a) Potential free contacts for the following:
   - All the reference cells failed. (Contact open on alarm condition)
   - Pipeline overprotected. (Contact open on alarm condition)
   - Pipeline under protected. (Contact open on alarm condition)
   - System in auto-mode. (Contact close in auto condition)
   - System in CVCC mode. (Contact close in CVCC mode)
b) 4 to 20 mA electrically isolated signal for the following:
   - PSP (-4V to OV)
   - CPPSM output voltage
   - CPPSM output current

The transducers shall have electrical isolation between input and output. The isolation insulation shall withstand 2 kV, 50 Hz for minimum 1 minute. The accuracy class of the transducer shall be 0.5. The transducers shall be protected against input and output voltage surges. The transducer shall be suitable for driving up to 600 ohms load impedance located up to 500 m away and wired with 0.5 mm- copper conductor cable. The transducers shall be suitable for minimum 125% continuous over load in the input voltage/current parameter.

6.6.6 For units having multiple outputs, each output circuit shall have independent controls, indication and metering.

7.0 TESTS AND ACCEPTANCE

7.1 During fabrication, the equipment shall be subjected to inspection by owner or his authorised representative to assess the progress of the work as well as to ascertain that only quality raw materials are used for the same. He shall be given all assistance to carry out the inspection.

7.2 Final acceptance test shall be carried out at manufacturer's works under his care and expense. Instruments and equipments required for testing shall be arranged by manufacturer. Owner's representative shall be given minimum 2 weeks prior notice for witnessing the tests. Test certificates indicating test results shall be furnished by the manufacturer. Acceptance tests shall include but not be limited to the tests listed below.

7.2.1 Visual Inspection

This shall include-
   - Completeness of the equipment in line with specification.
   - Checking of all settings.
   - All labels provided and satisfactory.
   - Dimensional checking.
   - Proper mounting of components and neatness of wiring etc.
   - Model number.

7.2.2 Insulation tests

The voltage specified in the table below shall be applied for one minute to the circuits indicated:

<table>
<thead>
<tr>
<th>Withstand voltage</th>
<th>Control electronics &lt;60V</th>
<th>Power electronics Un₁</th>
<th>Auxiliary circuits Un₂</th>
</tr>
</thead>
</table>

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<table>
<thead>
<tr>
<th>To earth</th>
<th>700 V D.C.</th>
<th>2xUn₁ + 1000V</th>
<th>2xUn₂ + 1000V</th>
</tr>
</thead>
<tbody>
<tr>
<td>To control electronics</td>
<td>-</td>
<td>2xUn₁ + 1000V</td>
<td>2xUn₂ + 1000V</td>
</tr>
<tr>
<td>To power electronics</td>
<td>2xUn₂ + 1000V</td>
<td>-</td>
<td>2xUn₂ + 1000V</td>
</tr>
<tr>
<td>To auxiliary circuits</td>
<td>2xUn₂ + 1000V</td>
<td>2xUn₁ + 1000V</td>
<td>-</td>
</tr>
</tbody>
</table>

(Un₁ and Un₂ are nominal voltage rating of power electronics and auxiliary circuits respectively).

D.C. test voltages may be applied instead of A.C. The magnitude of D.C. test voltages to be applied shall be 2 times the above-mentioned A.C. (r.m.s) Values.

Insulation resistance test shall be conducted before and after heat run test.

### 7.2.3 Heat run test

All CPPSMs shall be subjected to a heat run test performed at rated voltage for period not less than 16 hours prior to execution of functional tests.

At least one CPPSM of each rating shall be loaded to its rated output throughout 16 hour test period. All other CPPSMs shall be energized under partial load or zero load current condition throughout the test period.

### 7.2.4 Functional tests

Functional tests as below shall be performed on each CPPSM. If during execution of functional tests, any electronic component of the unit is required to be replaced e.g. due to malfunction or failure of the unit to fulfil the performance requirements of the specification, then the load test shall be repeated at rated current following which functional tests shall be carried out.

#### 7.2.4.1 CVCC mode operation testing

a) **Constant voltage operation**

During the test, current limit shall be set to rated output current. Performance testing shall be carried out for various output voltage settings and load varying from zero to maximum. The verification of operation of the control functions, measurement of output voltage, current, input voltage, current, ripple in the output, input, evaluation of output voltage regulation and efficiency of the unit shall be carried out during the testing.

b) **Constant current operation**

During the test, voltage limit shall be set to rated output voltage. Performance testing shall be carried out for various output current limit settings and load resistance varied to achieve output voltage from minimum to maximum. The verification of operation of the control functions, measurement of output voltage, current, input voltage, current, ripple in the output, input, evaluation of output current regulation of the unit shall be carried out during the testing.

#### 7.2.4.2 Auto PSP mode operation
Suitable set-up shall be arranged for output loading and reference cell feedback. The closed loop performance and regulation shall be checked with the PSP set voltage varied from 0.85V to 1.2V.

Disconnecting the reference cell feedback connection in the above set up shall simulate the reference cell failed condition. The output voltage/current of the unit shall go to the value set on the potentiometer Vas/ias provided inside the CPPSM. The settings on Vas/ias shall be varied and the output voltage/current shall be observed.

7.2.4.3 Operation of sensors for pipeline over protection, under protection, reference cell failure and reference cell selection logic in auto PSP mode shall be verified by connecting variable external voltage sources to reference cell inputs of the CPPSM. The number of external voltage sources shall be same as number of reference cell inputs specified for the CPPSM.

7.2.4.4 The unit shall be checked for operation of the current limit by over loading the unit in both CVCC and auto PSP modes of operation. For Units where semiconductor fuses are not provided for protection of the power semiconductor device, the protection of same shall be tested as below:

A switch rated for making and carrying CPPSM output short circuit current shall be connected to the output terminals of the unit. The output voltage and the output current limit settings of the unit shall be set to the maximum rated values. The switch connected in the output shall be shorted quickly.

The unit shall go to current limit mode and shall not damage any active component of the unit.

7.2.4.5 The current interrupter shall be tested for time interval settings and specified operation.

8.0 PACKING AND DESPATCH

The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight' etc., shall be clearly marked on the package together with Tag nos., P.O. Nos. etc.

The equipment may be stored outdoors for long periods before erection. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature.

9.0 DEVIATIONS

9.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
TECHNICAL SPECIFICATION

CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT
## CONTENTS

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1.0 SCOPE

This specification covers the requirements for the design, manufacture and testing of Cathodic Protection Transformer Rectifier units (CPTR units) working on controlled rectification principle intended to supply power to cathodic protection system for underground pipelines/structures.

2.0 CODES AND STANDARDS

2.1 The system design, performance and materials to be supplied shall conform to the requirements of the latest revision of following standards:

- **IS: 1248 (Parts-I, 2,8 & 9)** Direct acting indicating analogue electrical measuring instruments and accessories.
- **IS: 3700 (Parts-I to 11)** Essential rating and characteristics of semiconductor devices
- **IS: 3715 (Parts-I to 4)** Letter symbols for semiconductor devices
- **IS: 4411** Code of designation of semiconductor devices.
- **IS: 5469 (Parts-I to 4)** Code of practice for the use of semiconductor junction devices.
- **IS: 6619** Safety code for semiconductor rectifier equipment.
- **IS:7204 (Parts-I to 4)** Stabilized power supplies DC output
- **IS: 12021 (Parts-I to 4)** Control transformers for switchgear and control gear for voltages not exceeding 1000 V AC.
- **IS: 13703 (Parts-I to 4)** Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC.
- **IS/IEC:60947** Low voltage switchgear and control gear.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standards/ specifications and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- This specification.
- Codes and standards

3.0 SITE CONDITIONS

The CPTR unit shall be suitable for installation in non air-conditioned room with restricted ventilation or in outdoor kiosk, in locations having generally corrosive, warm, humid and dusty atmosphere. Service conditions shall be as actual site conditions. If not specifically mentioned therein, a design ambient temperature of 45°C and an altitude not exceeding 1000 m above mean sea level shall be considered.

4.0 GENERAL REQUIREMENTS
4.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.

4.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

5.0 TECHNICAL REQUIREMENTS

5.1 Fabrication and General Details

5.1.1 CPTR unit shall be housed in sheet steel enclosure. The front, rear walls and doors shall be made by using minimum 2 mm thick sheet steel and side walls shall be made of minimum 1.6 mm thick sheet steel. Wherever required, suitable stiffeners shall be provided. The Unit shall be freestanding type. Hinged doors shall be provided at the front and back as required. The unit shall be natural cooled type. Louvered openings with wire mesh for natural ventilation may be provided. Degree of protection for the panel shall be minimum IP-41. The CPTR unit panel shall, preferably, not need rear access for operation, maintenance and shall be suitable for mounting flushed to the wall.

5.1.2 Suitable hooks shall be provided for lifting the panel. These hooks when removed shall not leave any hole in the panel or imperfection in the paint finish.

5.1.3 All instruments shall be panel mounted type and back connected. All fuses shall be provided inside the panel and shall be of link type. 660 V grade PVC insulated BIS approved wires with stranded copper conductor of size minimum 2.5 mm² shall be used for power and auxiliary wiring. Control wiring for electronic circuits shall be through flat ribbon cable or through copper wire of minimum 0.5 mm diameter. All wirings shall be ferruled with PVC ferrules at both ends for ease of identification. Clamp type terminals suitable for termination up to 10 mm conductor shall be provided for all control cable connection. Suitable power terminals shall be provided for power cables. Minimum 20% spare terminals shall be provided. The terminal blocks shall be mounted minimum 300 mm above the gland plate.

5.1.4 All live parts shall be properly shrouded. This shall ensure complete safety to personnel intending routine maintenance by opening the panel doors.

5.1.5 CPTR unit shall be suitable for bottom cable entry unless otherwise specified and shall be supplied complete with crimping type cable termination lugs and cable glands. Cable glands shall be of rolled aluminium, single compression type for indoor installations and double compression type for outdoor installations. The space in the terminal chamber shall be adequate for termination of required number and sizes of cables.

5.1.6 The input power factor of the unit at rated load shall be 0.8 lag or better.

5.1.7 The CPTR unit shall be field proven. The design, internal component layout and rating of component shall ensure high MTBF and low MTTR. Prototype equipment shall not be acceptable.

5.1.8 All the control equipment like switches, pushbuttons, potentiometers etc. shall be located at a convenient height of minimum 300 mm and maximum 1800 mm from the bottom of the panel.

5.1.9 The printed circuit boards (PCBs) shall be of copper clad glass epoxy laminate. PCB tracks shall be tinned and solder masked. The PCB shall be coated with suitable lacquer to
make it immune to dust, moisture and fungal growth. Where plug in type of PCBs are used
gold plated male-female connectors shall be used for the purpose.

5.1.10  If required the panel shall be provided with space heater to prevent moisture condensation.
The space heaters shall be located at the bottom of the panel, and shall be provided with a manually operated switch, HRC fuse and link for phase and neutral respectively. The space heater shall have porcelain connectors. Where space heater is not provided the electronic PCBs/components and other control devices shall be made immune to moisture condensation.

5.1.11  Panel shall be provided with integral base frame channel. The integral base frame of panel shall be suitable for directly bolting with the help of foundation bolts and shall also be suitable for tack welding to purchaser's insert plate/flat/channel embedded in the floor. Amply dimensioned oblong holes shall be provided at the bottom of the panel for its bolting to the embedded insert plate/channel.

5.1.12  An earth bus bar of minimum (25 x 3) m² copper or equivalent aluminium shall be provided throughout the length of the panel. Provision shall be made for connecting this earth bus at two ends with the plant earth grid by means of (40x5) mm- GI flat. All non-current carrying metallic parts of the panel and mounted equipment shall be connected to the panel earth bus. All doors and movable parts shall be connected to the earth bus by flexible copper cables.

5.1.13  All panel mounted equipments (e.g. lamps, pushbuttons, switches, meters, PCBs, etc.) shall be provided with suitable nameplates. Nameplates shall be engraved out of 3-ply (black-white-black) lamicoid sheets or anodised aluminium. Back-engraved Perspex sheet nameplates may also be acceptable. Engraving shall be done with groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable. Nameplates shall be fastened by screws and not by adhesive. Labels shall be provided for every component on the cards, connecting wires as well as for the terminals in the terminal strip inside the panel.

5.1.14  Where specified, the CPTR unit shall be housed in an outdoor kiosk. The kiosk shall be made of sheet steel of minimum 3 mm thick and epoxy painted on both internal and external surfaces. Hinged lockable doors shall be provided at the front and back. The kiosk shall be suitable for outdoor mounting and shall give proper protection to the CPTR unit against rain, other harsh weather conditions. Necessary ventilation arrangement with louvers and wire mesh shall be provided for proper operation of the CPTR unit. The cable entry to the kiosk shall be from bottom through cable glands. Suitable canopy shall be provided on the top of the Kiosk.

5.1.15  **Painting**

All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt.

Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under surface shall be made free from all imperfections before undertaking the finishing coat.

After preparation of the under surface, the panel shall be spray painted with two coats of final paint or shall be powder coated. Colour shade of final paint shall be approved by the purchaser before final painting is started. The finished panels shall be dried in stowing ovens in dust free atmosphere. Panel finish shall be free from imperfections like pin holes, orange peels, run off paint, etc. All unpainted steel parts shall be suitably treated to prevent corrosion. If these parts are moving elements, then they shall be greased.
6.0 EQUIPMENT DESCRIPTION

The CPTR unit shall be complete with following main sections:
- Transformer and input controls.
- Rectifier and filter
- Output protections
- System controls
- Control, indication and metering

6.1 Transformer and Input Controls

6.1.1 The transformer shall be natural cooled dry type with separate primary and secondary windings.

An intermediate earth screen shall be provided between primary and secondary windings. CPTR Units having multiple output circuits shall have separate secondary windings for each output circuit. Transformer shall be vacuum impregnated with epoxy varnish and baked. The safety factor for transformer rating shall be minimum 125%.

6.1.2 Single-phase transformers may be provided up to 50V, 50A DC output rating of the CPTR units. Beyond this rating, 3 phase transformers shall be provided. A moulded case circuit breaker with thermal over load and short circuit release shall be provided at the input of the transformer. Miniature circuit breaker with thermal overload and short circuit release in place of moulded case circuit breaker may be provided, where the miniature circuit breaker rated for the incoming AC supply short circuit current.

6.2 Rectifier and Filters

6.2.1 The rectifier shall be made of thyristors and diodes as basic components. The CPTR unit shall be suitable for 415 V AC, 3-ph power supply. Rectifier shall be 3 phase full wave type and controlled type. For CPTR units rated 50V, 50A DC or less, the unit may be suitable for 240V AC, 1 ph power supply and the rectifier shall be full wave type and controlled type. Alternatively, for single phase AC CPTR units, diode rectifier of full wave type in the secondary of the transformer and triac or back to back connected thyristors in the transformer primary AC supply circuit may be provided. The current and voltage ratings of thyristors, diodes shall be at least two times the actual maximum device current and minimum two times the actual maximum voltage coming across the device respectively. The thyristors/ triac/ rectifier elements shall be protected against voltage surges coming from the incoming power supply and from output side from the pipeline. Required shunt zeners / MOV shall be provided across the rectifier elements for protection.

The rectifier elements shall have humidity/moisture resistant finish and mounted in sufficiently sized heat sink designed to provide adequate cooling under worst conditions of operation. The rectifier elements shall have adequate protection against high dv/dt and di/ dt. 6.2.2 The thyristors/triacs shall be protected by semiconductor fuses. For units rated 50V, 50A DC or less, if the thyristors or triacs are adequately over rated and system has enough inductance so that in case of sudden output short circuit the over current limit feature comes into action before short circuit current rises beyond the rating of the thyristors/triacs, then the semiconductor fuses may not be provided. This feature shall be demonstrated during testing of the unit at works.

6.2.3 Adequate filtering shall be provided on the DC output of the rectifier to limit the ripple content in the output to less than 5% at rated output.

6.2.4 The rectifier system shall be of natural air cooled type.

6.2.5 For CPTR units with multiple output circuits, each output circuit shall have independent rectifier and filter.
6.3 Output Protections

Two pole moulded case circuit breaker or miniature circuit breaker (if available) rated for the DC output current, short circuit current and having thermal over load, short circuit release shall be provided in the output. A lightning arrester rated for minimum 10KA impulse current discharge capacity and rated voltage & maximum spark over voltage rating suitable to protect the CPTR unit components against lightning and switching surges shall be provided at the output. For CPTR units with multiple output circuits, each output circuit shall be provided with circuit breaker and lightning arrester.

6.4 System Controls

6.4.1 The CPTR unit shall have two distinct modes of operation (independent for each output circuit) as below:

a) Constant Voltage and Constant Current Mode (CVCC)

In this mode the output voltage of CPTR unit shall be continuously adjustable from 0.5V DC to the rated output voltage. The set output voltage (Vos) shall remain constant irrespective of output current. Current limit feature shall be provided. The current limit (los) shall be continuously adjustable from zero to rated output current.

For constant voltage mode of operation the output current limit shall be set at maximum and output voltage setting shall be varied. Irrespective of output current demand the chosen value of the output voltage shall be maintained by the control system till the current limit is reached. After that the output current limit shall be maintained and output voltage shall decrease to keep the current constant.

For constant current mode of operation the output voltage shall be set at maximum and output current shall be varied through varying the setting of output current limit. Irrespective of output voltage requirement the control system shall maintain the output current to the set current limit value till the voltage limit is reached. After that the output voltage limit shall be maintained and output current shall decrease to keep the voltage constant.

b) Auto PSP Mode

In this mode of operation the output of the CPTR unit shall operate in an external closed loop with pipe to soil potential (PSP), measured by reference cell, in feedback loop. The CPTR unit control shall adjust the output voltage such that the PSP as measured by reference cell always remains equal to the set potential on the unit. The set potential (Vps) shall have high long time stability and minimum temperature drift. The set potential shall be continuously adjustable over the range required.

The unit shall be designed to operate with number of reference cells connected to it (to be provided by others). In case of more than one reference cell being specified, CPTR unit shall have feature to automatically select the reference cell having less negative potential than the others and use the same for auto control of the unit (e.g. (-) 0.8 V is less negative than (-) 0.9 V). Adequate hysteresis shall be provided in selecting the less negative potential reference cell, to avoid hunting between the reference cells at change over conditions.

In case of open circuit or short circuit of reference cell or potential being less negative than a minimum set potential (Vrs), the unit shall sense these conditions as reference cell failure and shall automatically switch over to the other healthy reference cell for control. Should fault occur in all the reference cells, the output voltage or current of
the CPTR unit shall adjust automatically to a preset value (Vas/ias), which shall be adjustable.

In both CVCC and auto PSP modes of operation a fast acting electronic over current limit protection shall be provided. This protection shall be fast enough to protect the active devices of the unit and fast enough to act before tripping of MCCB/MCB or blowing of fuse.

6.4.2 The unit shall continuously monitor the PSP and necessary annunciation shall be provided in case of PSP either exceeding the specified maximum limit (Vpm) or remaining lower than the specified minimum limit (Vpn).

6.4.3 The output voltage regulation for no load to full load variation with input voltage variation from maximum to minimum shall not be more than 2.5 % of rated voltage throughout the range of output voltage and over the specified ambient temperature variation, in CVCC-constant voltage mode of operation. In auto PSP mode the closed loop PSP regulation for no load to full load variation with input voltage variation from maximum to minimum and PSP feedback varying over the specified range shall be within Zf mV.

In CVCC-constant current mode of operation, the current regulation for minimum to maximum output voltage and minimum to maximum variation in input voltage shall not be more than 2.5% throughout the range of output current.

6.4.4 The DC output of the CPTR unit shall be floating (ungrounded) in the Unit. However the CPTR Unit shall allow grounding of positive output terminal through the anode ground bed.

6.4.5 For CPTR units with multiple output circuits, each output circuit shall have independent control system.

6.5 Current Interrupter

6.5.1 If required, a current interrupter for CPTR Unit output current interruption shall be provided.

6.5.2 The current interrupter shall have an output contactor with current rating minimum 125% of the output current rating of the CPTR unit and a digital timer to operate it.

6.5.3 The timer shall have 'ON' and 'OFF' timings. When the timer is turned on the 'ON' timing shall start and shall close the output contactor till the end of the 'ON' timing. At the end of the 'ON' timing the 'OFF' timing shall start and keep the contactor open till the end of the 'OFF' timing. At the end of the 'OFF' timing the 'ON' timing shall start again and close the output contactor. This process of 'ON' and 'OFF' timing shall continue.

6.5.4 The 'ON' and 'OFF' timings of the timer shall be settable by separate 2 digit thumbwheel switches, each settable from 1 to 99 seconds. The timing error of the timer shall be less than 5 parts per million. In case of microprocessor based system keypad with display may be provided in place of thumbwheel switches.

6.5.5 Whenever the timer is switched on it shall always start with ON 'timing'. A timer-reset push button shall be provided. On pressing this pushbutton during operation of the timer, the timer shall get reset and upon release of the button the timer shall restart with 'ON' timing.

6.5.6 The power required for operation of the timer and contactor shall be derived from the main power supply to the CPTR unit.

6.5.7 The following controls and indications shall be provided for current interrupter. The controls shall be housed in a lockable cover, so that normally they are not accessible. The indications shall be mounted on the door.
a) Controls
   - Timer power 'ON' / 'OFF'
   - Timer reset
   - Thumb wheel switch for 'ON' timing
   - Thumb wheel switch for 'OFF' timing

   In case of microprocessor based system keypad with display may be provided in place of thumbwheel switches.

b) Indications (LED)
   - Timer power 'ON'
   - 'ON' timing
   - 'OFF' timing

6.5.8 The output contact of the current interrupter contactor shall be wired in the positive DC output of the CPTR unit. A link shall be provided for shorting these terminals whenever the current interrupter is not in use.

6.5.9 If required the current interrupter shall be an independent unit of portable type. The interrupter unit shall have terminals for input power supply and terminals of the output contactor. The input power supply and the rating of the output contactor shall be as required. Terminals shall be provided in the CPTR unit for taking power supply to the current interrupter.

6.5.10 Where the current interrupter is not specified with CPTR unit or is specified as portable type external to the CPTR unit, then the CPTR unit shall have provision/ terminals for connection of input power supply and output contacts of external current interrupter, for current interruption test. A link shall be provided for shorting the output terminals provided in CPTR unit whenever the current interrupter is not connected.

6.5.11 For CPTR units with multiple output circuits, each output circuit shall have independent current interrupter.

6.6 Controls, Indication and Metering

6.6.1 Following controls shall be provided on CPTR unit front door.
   a) ON/OFF control for input through MCCB/MCB.
   b) ON/OFF control for output through MCCB/MCB.
   c) Auto/CVCC mode selector switch.
   d) Potentiometers for Vos, Vps and los settings.
   e) Selector switch for selecting indication of PSP set and PSP actual for all the reference cells.

6.6.2 Following controls shall be provided inside the module at user accessible common location:
   a) Potentiometer for Vrs, Vpm, Vpn and Vas/las settings.
   b) Controls for current interrupter:
      - Timer power 'ON' / 'OFF'
6.6.3 TR unit shall have following indicating lights (lamps or minimum 5 mm dia LEDs):

a) CPTR unit ON/OFF
b) Unit in auto/CVCC (2 lamps)
c) Reference cell controlling the closed loop control of the CPTR unit (number of lamps same as number of reference cells).
d) Reference cell faulty (number of lamps same as number of reference cells).
e) Pipeline over protected.
f) Pipeline under protected
g) Indications for current interrupter:
   - Timer power 'ON'
   - 'ON' timing
   - 'OFF' timing

It shall be possible to switch-off all the indication lamps by a single switch. In case of LED indication lights this facility may not be provided.

6.6.4 Following meters having min cl.1.5 accuracy shall be provided on the CPTR unit:

a) Digital meter for output voltage
b) Digital meter for output current
c) Digital voltmeter to measure PSP set (Vps) and PSP actual for all the reference cells. The meter shall have range from -4 V to 0 V and shall have cl.0.5 accuracy.
d) Digital meters for measuring Vrs, Vpm, Vpn and Vas/ias settings.
e) Meters for input voltage and current

It shall be possible to switch-off all the digital meters preferably by a single switch.

6.6.5 If required, CPTR unit shall incorporate provision for remote monitoring of the unit through SCADA system as below:

a) Potential free contacts for the following:
   - All the reference cells failed. (Contact open on alarm condition)
   - Pipeline overprotected. (Contact open on alarm condition)
   - Pipeline under protected. (Contact open on alarm condition)
   - System in auto-mode. (Contact close in auto condition)
   - System in CVCC mode. (Contact close in CVCC mode)
6.6.6 For units having multiple outputs, each output circuit shall have independent controls, indication and metering.

7.0 TESTS AND ACCEPTANCE

7.1 During manufacture, the equipment shall be subjected to inspection by owner or his authorised representative to assess the progress of the work as well as to ascertain that only quality raw materials are used for the same. He shall be given all assistance to carry out the inspection.

7.2 Final acceptance test shall be carried out at manufacturer's works under his care and expense. Instruments and equipments required for testing shall be arranged by manufacturer. Owner's representative shall be given minimum 2 weeks prior notice for witnessing the tests. Test certificates indicating test results shall be furnished by the manufacturer. Acceptance tests shall include but not be limited to the tests listed below.

7.2.1 Visual Inspection

This shall include-
- Completeness of the equipment in line with specification.
- Checking of all settings.
- All labels provided.
- Dimensional checking.
- Proper mounting of components and neatness of wiring etc.
- Model number.

7.2.2 Insulation tests

The voltage specified in the table below shall be applied for one minute to the circuits indicated:

<table>
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<tr>
<th>Withstand voltage</th>
<th>Control electronics (&lt;60V)</th>
<th>Power electronics (Un_1)</th>
<th>Auxiliary circuits (Un_2)</th>
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<tr>
<td>To earth</td>
<td>700VD.C.</td>
<td>(2\times Un_1 + 1000V)</td>
<td>(2\times Un_2 + 1000V)</td>
</tr>
<tr>
<td>To control</td>
<td></td>
<td>(2\times Un_1 + 1000V)</td>
<td>(2\times Un_2 + 1000V)</td>
</tr>
<tr>
<td>electronics</td>
<td></td>
<td>(\text{-})</td>
<td>(\text{-})</td>
</tr>
<tr>
<td>To power</td>
<td>(2\times Un_2 + 1000V)</td>
<td>(\text{-})</td>
<td>(\text{-})</td>
</tr>
</tbody>
</table>
electronics | To auxiliary circuits | 2xUn₂ + 1000V | 2xUn₁ + 1000V | -

(Un₁ and Un₂ are nominal voltage rating of power electronics and auxiliary circuits respectively).

D.C. test voltages may be applied instead of A.C. The magnitude of D.C. test voltages to be applied shall be 2 times the above-mentioned A.C. (r.m.s) Values.

Insulation resistance test shall be conducted before and after heat run test.

7.2.3 Heat run test

All CPTR units shall be subjected to a heat run test performed at rated voltage for period not less than 16 hours prior to execution of functional tests.

At least one CPTR unit of each rating shall be loaded to its rated output throughout 16 hour test period. All other CPTR units shall be energized under partial load or zero load current condition throughout the test period.

7.2.4 Functional tests

Functional tests as below shall be performed on each CPTR unit. If during execution of functional tests, any electronic component of the unit is required to be replaced e.g. due to malfunction or failure of the unit to fulfil the performance requirements of the specification, then the load test shall be repeated at rated current following which functional tests shall be carried out.

7.2.4.1 CVCC mode operation testing

a. Constant voltage operation

During the test, current limit shall be set to rated output current. Performance testing shall be carried out for various output voltage settings and load varying from zero to maximum. The verification of operation of the control functions, measurement of output voltage, current, input AC voltage, current, power factor, ripple in the output, evaluation of output voltage regulation and efficiency of the unit shall be carried out during the testing.

b. Constant current operation

During the test, voltage limit shall be set to rated output voltage. Performance testing shall be carried out for various output current limit settings and load resistance varied to achieve output voltage from minimum to maximum. The verification of operation of the control functions, measurement of output voltage, current, input AC voltage, current, power factor, ripple in the output, evaluation of output current regulation of the unit shall be carried out during the testing.

7.2.4.2 Auto PSP mode operation

Suitable set up shall be arranged for output loading and reference cell feedback. The closed loop performance and regulation shall be checked with the PSP set voltage varied from 0.85V to 1.2V.

Disconnecting the reference cell feedback connection in the above set up shall simulate the reference cell failed condition. The output voltage/current of the unit shall go to the value set on the potentiometer Vas/Ias provided inside the CPTR UNIT. The settings on Vas/Ias shall be varied and the output voltage/current shall be observed.
7.2.4.3 Operation of sensors for pipeline over protection, under protection, reference cell failure and reference cell selection logic in auto PSP mode shall be verified by connecting variable external voltage sources to reference cell inputs of the CPTR unit. The number of external voltage sources shall be same as number of reference cell inputs specified for the CPTR unit.

7.2.4.4 The unit shall be checked for operation of the current limit by over loading the unit in both CVCC and auto PSP modes of operation. For Units where semiconductor fuses are not provided for protection of the thyristors/triacs, the protection of same shall be tested as below:

A switch rated for making and carrying CPTR unit output short circuit current shall be connected to the output terminals of the unit. The output voltage and the output current limit settings of the unit shall be set to the maximum rated values. The switch connected in the output shall be shorted quickly.

The unit shall go to current limit mode and shall not damage any active component of the unit.

7.2.4.5 The current interrupter shall be tested for time interval settings and specified operation.

8.0 PACKING AND DESPATCH

The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight' etc., shall be clearly marked on the package together with Tag nos., P.O. Nos. etc.

The equipment may be stored outdoors for long periods before erection. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature.

9.0 DEVIATIONS

9.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
TECHNICAL SPECIFICATION

IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM

FOR PIPELINES
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1.0 SCOPE

1.1 This specification defines the requirements of system design, engineering, installation, testing and commissioning of an Impressed Current Cathodic Protection System for underground pipelines / structures including supplementing of corrosion survey, close interval potential logging survey, investigations for interaction/interference problems and mitigation of the same.

1.2 This specification provides the basic parameters to develop a suitable impressed current cathodic protection system for the pipelines/structures requiring protection. LSTK contractor shall include, site survey to collect required information, design, supply, installation, commissioning of impressed current cathodic protection system. All data required in this context shall be taken into consideration to develop an acceptable design and for proper engineering of the system.

1.3 In addition to this specification, other requirement, if any, for complete cathodic protection shall be considered by LSTK contractor.

1.4 Compliance with these specifications, and/or approval of any documents submitted by contractor shall in no case relieve the contractor of his contractual obligations.

2.0 CODES AND STANDARDS

2.1 The system design, performance and materials to be supplied shall conform to the requirements of the latest revision of following standards as a minimum:

i) NACE Standard RP-0169 : Standard Recommended Practice Control of External Corrosion on Underground or Submerged Metallic Piping Systems

ii) NACE Publication l0A190 : Measurement technique related to criteria for CP of Underground or Submerged Steel Piping System (as defined in NACE Standard RPO169-83)

iii) NACE Standard RP-0177 : Standard Recommended Practice Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems

iv) NACE Standard RP-0286 : Standard Recommended Practice The Electrical isolation of Cathodically Protected Pipelines.

v) NACE Publication No. 54276 : Cathodic Protection Monitoring for Buried Pipelines.

vii) DNV RP-B403 : Recommended Practice Monitoring of Cathodic Protection Systems

viii) DNV RP-B401 : Recommended Practice Cathodic Protection Design

ix) IS 8062 : Recommended Practice ICCP for Underground Piping

x) BS 7361 Part I : Code of Practice for Cathodic Protection for land and marine application.

xi) VDE 0150 : Protection against Corrosion due to Stray Current from DC Installations.

xii) IS: 1554 Part I : PVC insulated (heavy duty) cables.

2.2 In case of imported equipments standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also confirm to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4. In case of any contradiction between various referred standards/specifications and statutory regulations the following order of priority shall govern:
- Statutory regulations
- This specification
- Codes and standards

3.0 SYSTEM IMPLEMENTATION

All work to be performed and supplies to be effected as a part of contract shall require specific review by Owner or his authorised representative. Major activities requiring review shall include but not be limited to the following:

i) Corrosion survey data interpretation report and plot plans for land acquisition.
ii) Conceptual system design.
iii) Basic engineering package.
iv) Detailed engineering package.
v) Field testing and commissioning procedures.
vi) Procedures for interference testing and mitigation
vii) Close interval potential logging survey procedure
viii) As built documents.

4.0 CORROSION SURVEY
4.1 General

4.1.1 The details of corrosion survey including soil resistivity data along ROW and other data required for C.P. design if available with the owner shall be included. However, verification of its veracity and adequacy shall be the entire responsibility of the contractor. In addition, contractor shall have to generate/collection additional data as per clause 4.4 below required for completeness of the job.

Contractor shall carry out soil resistivity survey at anode ground bed locations for design of ground bed. Contractor shall also carry out corrosion survey along the ROW of the pipeline.

4.1.2 To carry out soil resistivity measurement Wenner's 4-pin method or an equivalent method approved by Owner shall be used. Survey instruments shall have maximum AC and DC ground current rejection feature.

Care shall be taken to ensure that the resistivity observations are not influenced by the presence of foreign pipelines/structures, and earth currents in the vicinity of EHV/HV lines and installations using earth return in their power system etc.

4.2 Soil Resistivity Survey at Impressed Current Anode Ground Bed Plot

4.2.1 Each selected anode bed plot shall be sub-divided into sub-plots. Sizes of sub-plots shall depend upon the expected depth for soil resistivity investigations. Each of these sub-plots shall be investigated for resistivity data individually. Sufficient observations shall be taken at each of these sub-plots as required and desired by Owner/Owner's representative to obtain sufficient information about sub-soil stratification and, wherever possible, to establish the depth of water table. The number of subplots at each ground bed plot shall be decided at site in consultation with Owner/Owner's representative.

4.2.2 Number, location, demarcation and size of sub-plots and number of sets of resistivity observations required for each sub-plot shall be individually decided for each ground bed plot location.

4.2.3 One or more ground bed plots may be required to be selected and surveyed at each CP station to form a suitable ground bed.

4.3 Topographic Surveys

Cathodic protection stations consisting of anode ground bed, CP station, etc. As applicable, along with all associated cabling up to pipeline and any other related equipment and accessories for CP station shall be demarcated on the ground. Ground plots so demarcated shall be surveyed for all other topographical and cadastral features and topo-sheets shall be developed by the CONTRACTOR, which shall be suitable for use in land acquisition etc.

4.4 Additional Data to be Collected

The following data shall be collected to generate design data for evaluation of interaction/interference possibilities due to presence of other services in ROW or in its vicinity. OWNER shall provide assistance for liaison work to the extent possible.

i) Route and types of foreign service/pipeline in and around or crossing the right of way (including those existing and those which are likely to come up during contract execution).
ii) Diameter, wall thickness, pressure, soil cover, and coating scheme used, type of cathodic protection system provided, if any, year of laying/commissioning in case of foreign pipelines.

iii) Details of the existing cathodic protection systems protecting the services i.e. type of protection, location, type, rating of anode beds, test station locations and their connection schemes. Present output current and voltage readings of the CP power supply units.

iv) Remedial measures existing on foreign pipelines/services to prevent interaction.

v) Graphical representation of existing structure / pipe-to-solid potential records.

vi) Possibility of integration/isolation of CP systems, which may involve negotiations with owners of other services.

vii) Existing and proposed DC/AC power sources and systems using earth return path such as HVDC substations/ earthing stations, fabrication yards with electric welding etc. in the vicinity of the entire pipeline route.

viii) Crossing and parallel running of electrified and non-electrified traction (alongwith information regarding, operating voltage, AC/DC type etc.) as well as abandoned tracks near ROW having electrical continuity with the tracks in use.

ix) Crossing or parallel running of any existing or proposed EHV/HV AC/DC overhead power lines along with details of voltage, AC/DC type etc.

x) Voltage rating, phases, sheathing details of underground power cables along ROW or in its vicinity.

xi) Any other relevant information that may be needed in designing and implementing proper cathodic protection scheme for the proposed pipeline. Graphical representation of existing structure/ pipe-to-soil potential records.

Contractor shall conduct necessary potential gradient surveys for any existing anode ground beds that may interfere with the CP system of the pipelines covered under this project.

4.5 Report

On completion of all field work, a report incorporating all the results generated from surveys and details of additional data collected shall be prepared. The report shall also contain detailed interpretation of survey results and resistivity data, probable interference prone areas, selected locations for anode ground beds, etc., to form a design basis for the scheme of cathodic protection. This report shall also include various drawings prepared in connection with the above work. Soil resistivity values shall be plotted on semilog graph sheets.

5.0 CATHODIC PROTECTION DESIGN PARAMETERS

A distinctly independent impressed current cathodic protection system shall be provided to protect the external surfaces of the complete pipeline/structure installation as specified.

Unless otherwise stated, the following parameters shall be used for design of permanent cathodic protection system:

5.1 Protection Current Density Range

i) Pipelines having coal tar coating with two/three layers of reinforcement.
## TECHNICAL SPECIFICATION - IMPRESSED CURRENT CATHODIC PROTECTION SYSTEM FOR PIPELINES (PC150-TS-0825)

### Pipeline surrounding Minimum Protection Current Density* (A/m²)

<table>
<thead>
<tr>
<th>Pipeline surrounding</th>
<th>Minimum Protection Current Density* (A/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil resistivity 10 ohm m to 100 ohm.m</td>
<td>300</td>
</tr>
<tr>
<td>Soil resistivity less than 10 ohm.m</td>
<td>2000</td>
</tr>
<tr>
<td>Soil resistivity more than 100 ohm.m</td>
<td>200</td>
</tr>
<tr>
<td>Sea Water</td>
<td>5000</td>
</tr>
</tbody>
</table>

### ii) Pipe lines having fusion bounded epoxy coating:

<table>
<thead>
<tr>
<th>Pipeline surrounding</th>
<th>Minimum Protection Current Density* (A/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil resistivity 10 ohm m to 100 ohm.m</td>
<td>125</td>
</tr>
<tr>
<td>Soil resistivity less than 10 ohm.m</td>
<td>500</td>
</tr>
<tr>
<td>Soil resistivity more than 100 ohm.m</td>
<td>90</td>
</tr>
</tbody>
</table>

### iii) Pipe lines having polyethylene coating

<table>
<thead>
<tr>
<th>Pipeline surrounding</th>
<th>Minimum Protection Current Density* (A/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil resistivity 10 ohm m to 100 ohm.m</td>
<td>50</td>
</tr>
<tr>
<td>Soil resistivity less than 10 ohm.m</td>
<td>125</td>
</tr>
<tr>
<td>Soil resistivity more than 100 ohm.m</td>
<td>35</td>
</tr>
</tbody>
</table>

* Actual current density to be adopted shall be decided based upon soil and other environmental conditions, current drainage survey data, proximity of foreign pipe lines/structures and other interference areas affecting the installation. Where considered necessary for satisfactory protection of pipeline the current density shall be suitably increased by contractor. Also refer to clause 7.1 iv) below.

At HDD (horizontal direction drilling) crossing, the pipe protection current density applicable for marshy area shall be considered.

5.2 The pipe protection Current Density indicated in the clause 5.1 above shall be applicable where the temperature of the fluid transported by the pipeline/ the surface temperature of the buried portion of the pipeline does not exceed 30°C. Where this temperature exceeds 30°C, the protection Current Density shall be increased suitably in consultation with the Owner/PMC.

5.3 Safety factor for current density : 1.3

5.4 Anode utilisation factor : 0.85 for centre connected anode.

(For high silicon cast iron anode) 0.6 for end connected anode.

5.5 Anode surface current density : 10 Amp./Sq.m. (max.)

For high silicon cast iron anode

For continuous operation
5.6 Anode consumption rate : 0.2 Kg./Amp.yr.

5.7 Pipeline natural potential : (-) 0.45 V

5.8 Design life of CP System : 30 years

5.9 Anode ground bed loop resistance: 1 ohm (max.).

including anode to ground resistance, anode and cathode cable resistances.

(The output voltage rating of the CPTR unit /CPPSM shall in minimum be adequate to drive the specified end of life cathodic protection current with safety factor, considering the total anode ground bed loop resistance as the sum of the resistance specified in this clause and pipe to earth resistance).

5.10 For mixed metal oxide coated titanium anodes the anode utilisation factor, anode surface current density and anode consumption rate etc. shall be as per the guaranteed values published by the manufacturer and supported by test certificates/field proven ness.

6.0 CATHODIC PROTECTION DESIGN CRITERIA

Cathodic protection system shall be designed to meet the following criteria :

i) The pipe to soil potential measurements shall be between (-) 0.9V (OFF) and (-) 1.18V (OFF) with respect to a copper/copper sulphate reference electrode.

ii) In rare circumstances, a minimum polarisation shift of (-) 100 millivolts may be accepted as an adequate level of cathodic protection for the pipeline with the approval of Owner.

iii) A positive potential swing of 100 millivolts or more shall be considered sufficient to indicate the presence of an interaction/interference situation requiring investigation and incorporation of mitigation measures by the CONTRACTOR.

7.0 SYSTEM DETAILS

The system shall include the following major equipment/sub-systems unless otherwise specified in project specifications:

- CP stations
- CPTR units/cathodic protection power supply modules (CPPSM)
- Anode ground beds and anodes
- Anode junction box
- Cathode junction box
- Test stations
- Permanent reference cells
- Electrical resistance probes
- Polarisation cell and surge diverter
- Polarisation coupons
All equipment shall be new and procured from approved reputed manufacturers. Equipment offered shall be field proven. Equipment requiring specialised maintenance or operation shall be avoided as far as possible. Prototype equipment shall not be accepted.

All equipment/materials shall conform to the relevant specifications included in the tender document.

All equipment including CPTR unit, CPPSM, test stations, anode lead junction boxes etc. shall be located in safe non-hazardous areas.

Where it is essential to install the equipment in hazardous area, such equipment shall be flame proof type and shall meet the requirement of IS: 2148, 5572 or equivalent international standard and shall be suitable for gas group, temperature class T3 (200°C). Indigenous equipment shall be certified by CMRI or any other recognised testing body and shall be approved by the concerned statutory authority. All flameproof equipment shall carry the BIS license marking as per the requirement of statutory authorities.

All Imported equipment for hazardous area may be tested and certified by an independent certifying agency of country of equipment origin and shall be approved by the concerned statutory authority in India.

7.1 Cathodic Protection Stations

The number and exact locations of CP stations shall be worked out based on the corrosion survey data collected. In addition, the following guidelines shall be followed for selecting the locations:

i) Number of CP stations and their selected locations shall ensure that these remain valid and are adequate for the full design life of the system after considering all foreseeable factors.

ii) As far as possible, the availability of nearby low resistivity areas for location of associated ground beds must be ensured while selecting the locations of CP stations.

iii) As far as possible, locations of intermediate CP stations shall coincide with the locations of SV stations.

iv) The locations of CP stations and anode ground bed current ratings shall be suitably selected. The same shall be verified for adequacy by the contractor. The requisite current drainage tests/survey shall be conducted by the contractor to establish the adequacy of CP current requirement indicated in clause 5.0 above and adequacy of number, ratings of CP stations for permanent CP system selected. The minimum end of life pipe protection current requirement shall be considered as the current requirement indicated in the clause 5.0 above or 3 times the current density value measured by the current drainage survey for polyethylene coated pipeline and 4 times the current density value measured by the current drainage survey for fusion bonded epoxy, coal tar enamel with reinforcement coated pipeline, whichever is maximum.

7.2 CP Transformer Rectifier Unit / CPPSM

The supply, installation, testing and commissioning of cathodic protection power supply module (CPPSM) / indoor type Cathodic Protection Transformer Rectifier Unit (CPTR unit)/
outdoor type CPTR unit installed in kiosk along with kiosk shall be included in contractor's scope. The CP TR units shall be provided at CP stations where reliable AC power supply is available. CPPSM shall be provided at other CP stations where reliable DC power supply instead of reliable AC power supply is available. The CPTR unit / CPPSM shall be installed in nonhazardous (safe) area.

For more details refer: 4001-TS-0823 & 4001-TS-0824

7.3 **Anode Ground Beds**

i) Each CP station shall have an independent anode ground bed, which may be of shallow or deep well construction depending upon the data collected by the contractor. Deep well ground beds may also be used in the congested locations where availability of suitable land for spread out ground beds is restricted.

ii) Ground bed shall be located electrically remote from the pipeline and foreign pipeline/other buried metallic structures. Nearest part of the anode bed shall at least be 100 meters away from the pipeline and foreign pipeline/other buried metallic structures. The anodes installed in the ground shall be located in perennially moist strata, wherever possible. Horizontal ground beds shall be at right angles to the pipeline, as far as possible.

The location of ground bed shall be checked and ensured for remoteness from the pipeline and other buried foreign pipelines/structures, building foundations, switchyards, electrical earthing systems, etc.

iii) Unless otherwise agreed, anodes shall be of high silicon cast iron type or mixed metal oxide coated titanium anodes.

iv) Sheet steel anode canisters of adequate size shall be provided for each anode. Anode canisters shall be filled with petroleum coke breeze. In case of deep well ground beds non-canistered anodes with petroleum coke breeze in the well surrounding the anodes shall be provided.

v) Each shallow anode-bed shall contain anodes with canisters positioned horizontally or vertically in the soil with suitable backfill. The depth of anodes (depth of top of anode in case of vertically laid anodes) shall not be less than 2 meter from grade level

vi) Layout of anode installation in anode bed shall be detailed out in drawings showing anode installation details, anode grouping, anode wiring, anode cable routing, etc. The deep well anode ground bed details shall include the details of anodes, deep well casing, anode positioning, anode cable supporting, deep well gas venting, active, passive portions of the ground bed, etc.

vii) Anodes shall be supplied complete with tail cables, which shall be long enough for termination on their associated anode lead junction boxes without intermediate joints. Exact lengths and termination details shall be indicated in construction drawings.

viii) Potential gradient around the anode bed shall be within safety requirements with regard to interference on foreign structures and its effective boundary shall be defined.

ix) In case of two parallel pipelines running in the same ROW, the anode ground beds of the respective pipelines shall be located on the respective sides of the pipelines.

7.4 **Anode Junction Box**
Depending on the size and configuration of anode ground beds, one or more anode junction boxes shall be provided at each ground bed. All cable tails from individual anodes shall be terminated onto the respective anode junction boxes, which shall be further connected to the main anode junction box (where applicable). The main anode junction box shall be connected to the cable coming from CP power source. Each outgoing circuit in main junction box (where applicable) and each anode circuit in junction shall have provision for measurement and control of individual circuit/anode current.

7.5 **Cathode Junction Box**

Where output of the CP power supply unit is connected to multiple pipelines a cathode junction box shall be provided near the pipelines at the location of connection of the negative drainage cable to the pipelines.

The negative of the CP power source shall be connected to the incoming circuit of the cathode junction box. The junction box shall have separate outgoing circuit one for each pipeline to collect the negative drainage currents from each of the parallel pipelines.

The incoming circuit shall have a current measurement facility. Each outgoing circuit shall have provision for measurement and control of current.

7.6 **Test Stations**

7.6.1 Test stations shall be provided along the pipeline ROW for monitoring the performance of the cathodic protection system at the following locations. Test stations shall be provided at additional locations, if required, so that distance between any two adjacent test stations does not exceed 1000 meters in inhabited areas and 2000 meters in uninhabited areas like forest/deserts:

i) At all insulating joints.
ii) At both sides of metallised road crossings.
iii) At vulnerable locations with drastic changes in soil resistivity.
iv) At locations of surge diverters, pipeline grounding through polarisation cells, zinc and magnesium anodes.
v) At EHV/HV AC/DC overhead line crossings and selected locations where EHV/HV overhead line is in the vicinity of the pipeline.
vi) At railway line crossings and at selected locations along lines running parallel to the pipeline.
vii) At both sides of major river crossings.
viii) At EHV/HV cable crossings or along routes where EHV/HV cables are running in parallel.
ix) In the vicinity of DC networks or grounding systems and HVDC grounding systems where interference problems are suspected.
x) At crossings of other pipelines/structures.
xi) At the locations of reference cell, electrical resistance probe and polarization coupon installation.

xii) At the location of computerised test stations.
xiii) At both sides of cased crossings.
xiv) Locations where interference is expected.

xv) At locations of sectionalising valve (SV) stations.

xvi) At any other locations considered necessary by Owner/Owner's representative.

7.6.2 Test stations for bonding shall be provided with shunt and resistor as a means to monitor and control current flow between the pipeline and foreign pipelines or structures that may exist in common ROW.

7.6.3 Test stations with current measuring facility shall be provided at each CP station drainage point (to measure pipeline current on anyone side of pipeline from drainage point at intermediate CP station and towards protected side of the pipeline at starting, end point CP stations), at interference prone areas, on both sides of major river crossings, near marshy areas and minimum one for every 10 km max. along the pipeline.

7.6.4 Test stations shall be installed with the face of the test station facing the pipeline. The nameplate of test stations shall carry the following minimum information:

- Chainage in km.
- Test station connection scheme
- Distance from pipeline in meter.
- Direction of product flow.

7.6.5 Number of terminals and different schemes of wiring shall be as per the test station connection scheme. Minimum twenty percent spare terminals shall be provided in each test station.

7.6.6 Minimum two cables from the pipeline shall be provided at any test station.

7.6.7 The location of all the test stations shall be marked with their connection schemes and other relevant information on alignment sheets. A detailed test-station schedule shall be prepared.

7.7 Permanent Reference Cells

7.7.1 High purity copper/copper sulphate reference cells with proven high reliability shall be provided for stable pipe to soil potential measurement at CP stations, polarization coupons and computerized test station locations along ROW.

7.7.2 Silver/Silver Chloride reference cells in place of copper/copper sulphate cells shall be provided at marshy area locations, where water table is high and chloride concentration is more than 300 ppm. The test station connection scheme shall clearly indicate the type of the reference electrode (Cu CUS04/Ag AgCl) at these locations.

7.7.3 The life of the reference cells shall be minimum 20 years under the installed conditions.

7.7.4 The cable from reference cells shall be provided up to CP power source at CP stations and up to test stations at the locations of polarization coupons, computerised test stations. The cable up to CP power source shall be routed through test stations near pipeline.

7.8 Electrical Resistance Probe

7.8.1 The electrical resistance probes (E/R probes) utilising the electrical resistance technique shall be provided along the pipeline at marshy areas and at vulnerable locations to monitor...
the external corrosion activity on the pipeline. The lead-wires of the probe shall be connected to pipeline through test station and terminated inside test station enabling periodic resistance measurement of the probe using a portable probe measuring instrument.

7.8.2 The material of the E/R probe element shall be of the same alloy as of the pipeline material. The probes shall be provided preferably at the bottom portion of pipeline.

7.8.3 Sufficient number of E/R probes, the locations of their installation and the number of portable E/R probe reading instruments shall be provided.

7.9 Polarisation Cell and Surge Diverter

7.9.1 Polarisation Cell

i) Where extra high voltage (66 KV and above) transmission line runs in parallel or crosses the pipeline, the pipeline shall be grounded through polarisation cell with zinc galvanic anodes of min. 20 kg net each. Grounding shall be done at regular intervals of maximum 1 km where transmission lines run parallel within 25 metres of the pipeline to control any surges in the pipeline potential that may appear in case of transmission line faults.

ii) Locations along pipeline where continuous induced over-voltage due to EHV/HV line etc. is expected or observed during commissioning, the pipeline shall be earthed through polarisation cell to the earth system of the EHV/HV tower causing the voltage induction or to a separate earthing system of zinc anodes through polarisation cell.

iii) Polarisation cell shall be installed inside test station of suitable size.

7.9.2 Surge Diverter

Explosion proof spark gap surge diverter shall be provided across each insulating joint to protect it from high voltage surges. surge diverters shall be provided for classified areas.

7.9.3 The total system including cables, cable termination, anodes/surge diverters, polarisation cell shall be suitable for the anticipated fault current at the location of installation.

7.9.4 The surge diverter and polarisation cell system shall be suitable for the design life of permanent CP system. The grounding system shall have minimum resistance to earth to restrict the pipeline voltage as per NACE/VDE criteria but shall not exceed 5 ohms.

7.9.5 The anodes shall be pre packed with special backfill adequately so that the performance of the anode is not affected by the carbonates, bicarbonates, nitrates, etc, present in the soil. In any case, the thickness of back fill shall not be less than 50mm on all the sides of the anode.

7.10 Motor operated valves where located on the cathodically protected portion of the pipeline shall be grounded by a zinc anode of 20 kg net. Magnesium anodes grounding, if any, provided during temporary CP system shall be disconnected. The MOV power supply cable armour shall be insulated (by cutting and taping with insulation tape) at MOV end to avoid armour carrying CP current.

7.11 The above ground cathodically unprotected pipeline at terminals, intermediate SV stations, pigging stations, etc. shall be earthed with GI earth electrodes. The resistance to earth of grounding shall be limited to 5 ohms max.

7.12 Polarisation Coupons
The steel coupons of pipeline material shall be provided along the pipeline to monitor the adequacy of the CP system to polarize/protect coating holidays. Coupon shall be installed at CP station drainage points, predicted cathodic protection mid points along the pipeline, at locations where the pipeline is bonded to foreign pipeline/structures, interference prone areas, marshy areas and at other locations such that minimum one coupon is installed maximum every 10 km approximately. Coupons shall be installed at bottom 113rd portion of the pipeline and 250 mm away from the pipe surface.

The coupons shall be constructed from the pipeline material and shall have uncoated surface of 100 mm x 100 mm exposed to soil. Two cables one for connection to pipeline for protection and other for potential measurement shall be provided for each coupon. The protection cable hall be connected through a magnetic reed switch inside the test station to enable measurement of coupon ‘OFF’ potential.

A permanent reference electrode shall be installed adjacent to the coupon in a manner so as to measure the representative potential of the coupon.

Magnets for operation of reed switch shall be provided.

7.13 Computerized Test Stations

Computerized test stations shall be provided along the ROW of the pipeline for automatically monitoring and recording the pipe to soil potential, pipe current, etc. of the pipeline, casing pipeline and foreign pipelines, etc. as required. The computer within the test station shall measure and record these parameters regularly at programmed intervals. The computers shall have required number of input ports for measurement of potentials and current as applicable at the location of its installation. Computers shall have real time clock and record the time of data measurement. Each computer shall an identification number incorporated in its software, which shall be clearly indicated along with the data display/print out.

The computers shall be programmed to collect and store all the field parameters at regular intervals.

Data-retrieval computer of portable type suitable for use in field for programming the field computers and retrieving the data stored by the field computers.

7.14 CP at Cased Crossing

7.14.1 At cased crossings where casing is coated, the casing shall be protected by sacrificial anode installations provided at both ends of casing. The anode installation shall be sized based on the permanent C.P. design parameters and design life of permanent CP system. At cased crossings where casing is uncoated or painted, additional protection for casing pipes may not be provided.

7.14.2 The carrier pipe inside the painted or coated casing shall be protected by zinc ribbon anodes weld connected to the outer surface of bottom of carrier pipe extending up to hour hand positions of 4 and 8 O'clock. The anodes shall be placed at close intervals as per design calculations with minimum one number of anode installed between every two supports provided between carrier and casing. The anodes shall be sized based on the permanent CP design parameters for marshy area and design life of permanent CP system.

7.14.3 Where casing is uncoated or unpainted additional protection for carrier pipe may not be provided.

7.15 Reference Cell Access Points
Reference cell access points shall be provided near insulating joint locations and at SV stations, where the ground is paved, for measurement of pipe to soil potentials. A perforated PVC pipe filled with native soil and buried at the location shall be provided for the purpose. The length of the PVC pipe shall be adequate to reach the native soil below the paving.

7.16 Cables

7.16.1 Cables shall be with annealed high conductivity stranded copper conductor, PVC insulated, 650/1100 V grade, armoured, PVC sheathed conforming to IS 1554 part-I, except for the cables for anode tail, reference cells and pipeline for potential measurements. The size of the copper conductor shall be minimum 35 sq.mm. for anode and cathode cables, 6 sq.mm. for current measurement, 10 sq.mm. for anode tail cables and polarization coupon protection cables. The size of cable for bonding, polarisation cell, grounding anodes and surge diverter connections shall be suitable for the maximum fault current subject to minimum 25 sq mm.

7.16.2 The anode tail cables shall be PE insulated, 650V grade, unarmoured, PVC sheathed and length shall be sufficient for termination on anode lead junction box without any joint in between.

7.16.3 The cables for reference cells, coupon and pipeline potential measurements shall be of 4 sq.mm copper conductor, PVC insulated, Aluminium backed by mylar/polyster tape shielded, PVC sheathed, armoured, PVC over all sheathed type.

1.16.4 The CPTR unit incomer cable shall be minimum 4 sq.mm. Copper conductor, 650/1100 V grade, PVC insulated, armoured, PVC sheathed. The cable shall be of 3 core type for single phase CPTR units and of 4 core type for 3 phase CPTR units.

7.16.5 The cables for connecting various transducers from CPTR unit/CPPSM to telemetry interface junction box shall be twisted pair with individual pair shielded and overall shielded with aluminium backed by mylar/polyster tape, PVC sheathed, armoured, PVC over all sheathed type.

8.0 INSTALLATION

8.1 Cable Laying

i) Cables shall be laid in accordance with layout drawings to be prepared by the contractor. No straight through joint shall be permitted. Cable route shall be carefully measured and cables cut to required length. Minimum half metre cable slack shall be provided near anodes, anode junction box, pipeline and test stations to account for any settling.

ii) All cables inside station/plant area shall be laid at a depth of 0.75 metre. Cables outside station/plant area shall be laid at a depth of minimum 1.5 metres. Cables shall be laid in sand under brick cover and back filled with normal soil. For cables laid outside the station/plant area, polyethylene warning mats shall be placed at a depth of 0.9 metre from the finished grade, to mark the route. iii) In case of above ground cables, all unarmoured CP cables shall be laid in GI conduits of sufficiently large size, up to accessible height for protecting against the mechanical damage.

iii) All underground unarmoured cables including anode tail cables shall run through PE sleeves. Distant measurement cables and permanent reference cell cables routed along the pipeline shall be carried at the top of the carrier pipe by securely strapping it at intervals with adhesive tape or equivalent as required.
iv) PVC pipes of proper size shall be provided for all underground cables for road crossings.

v) Cables shall be neatly arranged in trenches in such a manner that crisscrossing is avoided and final take-off to equipment is facilitated.

vi) The cables for reference cells and pipeline potential measurement shall be routed in a separate trench other than the trench provided for the rest of the CP system cables, AC cables for CPTR Units etc.

vii) The armour of the cables from CP station to test station (potential measurement, reference cell & drainage cables etc.), CP station to ground bed (anode cable) and test station to pipeline shall be earthed only at CP station end and test station end respectively of the cables. The cable armour shall be insulated (by taping with insulation tape) to avoid armour carrying CP current.

8.2 Permanent Reference Cells

The permanent reference cells shall be installed in natural soil conditions as per the recommendations of the cell manufacturer. Installations in highly acidic/alkaline soil and soil contaminated by hydrocarbons shall be avoided.

8.3 Cable to Pipe Connections

Connections of all cables other than cathode drainage cables to the pipeline or to charged pipelines shall be made by pin brazing. The resistance of the cable to pipe at the pin brazing connection point shall not exceed 0.1 ohm.

The cathode drainage cable shall be connected to a bolt welded to a metal plate, which is weld connected to the pipeline. The material of the plate shall be same as that of the material of the pipeline.

Pipe coating shall be repaired after connection of cable to pipeline. At cathode drainage point the cable joint including the bolt, metal plate and the exposed portion of the pipeline shall be covered by the coating repair material against ingress of water/moisture. The coating repair material shall be compatible with the original coating and shall prevent ingress of water along the cable surface and at the interface of coating repair with the original pipe coating.

8.4 Ground Bed Fencing

Chain link fencing shall be provided around the location of each ground bed/anode lead junction box.

9.0 FIELD TESTING AND COMMISSIONING

9.1 System testing at site

Field tests as per the reviewed field testing and commissioning procedures prepared by the Contractor shall be carried out on the equipment/systems before these are put into service. Acceptance of the complete installation shall be contingent upon inspection and test results. Field testing shall include but not be limited to the following:

i) Contractor shall carry out pre-commissioning operations after completion of installation of the system including all pre-commissioning checks, setting of all equipment, control and protective devices. All site tests, reliability and performance tests shall be carried out by Contractor.
ii) Before the electrical facilities are put into operation, necessary tests shall be carried out to establish that all equipment and devices have been correctly installed, connected and are in good working condition as required for the intended operation. Owner/Owners representative may witness all tests. At least one week's intimation notice shall be given before commencing the tests.

iii) All tools, equipment and instruments required for testing shall be provided by Contractor.

iv) Generally, the following minimum tests must be carried out and results shall be recorded:

- Visual Inspection : Comparison with drawings, specifications, detailed physical inspection and, if necessary, by taking apart the component parts.

- Testing : Simulation tests of equipment to determine

a) Cables

- Cable No.
- Voltage grade.
- Conductor cross section
- Continuity check
- Voltage test.
- Insulation resistance values between each core & earth, between cores (between core and earth for single core cable).

All cables shall be tested by 500 V megger.

b) E/R Probe

- Location/Identification number
- Checking of wiring as per schematics
- Resistance reading of probe
- Installed on top/bottom!side of the pipeline

c) Reference Cell

- Location
- Type of cell
- Potential reading
- Installed on top/bottom level of pipeline

d) Insulating joint

- Location
- Pipe to soil potential of both protected and non-protected sides of the insulating joint before and after energisation of CP system.

e) Surge diverter
- Location/identification number.
- Rating
- Type
- Check for healthiness.

f) Polarisation Cell
- Location/Identification number
- Rating
- Check for wiring
- Check standby current drain after CP system energisation. (Current drain with respect to voltage across the cell shall be recorded).
- Details of grounding provided for the polarisation cell.

g) Anode Ground Bed
- Location/Station
- Check for actual layout and compliance with drawings.
- Resistance of each individual anode.
- Current dissipation by each individual anode.
- Total resistance of complete anode bed.
- Mutual interference.

h) Computerised test station
- Location/Identification number
- Checking of wiring as per schematics
- Checking programmed interval for collection of the field data by the computer
- Type of reference cell

i) Polarisation Coupons
- Location
- Exposed area/size of coupon.
- Coupon to soil 'ON' and 'OFF' potentials.
- Type of reference cell.
- Magnetic reed switch rating.
9.2 CP Commissioning Procedure

A model commissioning procedure for a three stations CP system of a pipeline is given below for general guidance. Contractor shall develop detailed commissioning procedure as per this guideline.

i) On completion of installation of anode beds and other systems as envisaged in this specification, they shall be individually checked, tested and compared against the agreed specifications and procedure.

ii) Electrical continuity of the entire pipeline shall be verified in conformity with design.

iii) Input resistance of the pipeline at all the drainage points shall be checked and recorded.

iv) All current measuring test stations shall be calibrated and recorded using portable battery, variable resistances, voltmeters, ammeters, etc. as required.

v) Temporary protection facilities provided (if any) which do not form part of permanent CP shall be disconnected from the system & removed unless agreed otherwise.

vi) Anodes provided for grounding at the MOVs on cathodically protected portion of the pipeline shall be disconnected. Sacrificial anode where provided for the protection of the casing pipe at cased crossings shall be disconnected.

vii) The pipeline shall be allowed to depolarize for at least 72 hours after switching ‘OFF’ the protection (if any) of all other pipelines in the common ROW.

viii) Before the pipelines are put on charge by switching 'ON' any of the CP stations, natural pipeline to soil, casing pipe to soil and coupon to soil potential values at all the test stations of the system (coupon to soil potential at the locations of the coupon installations) shall be measured with respect to Copper/Copper Sulphate half cell.

ix) CP station no.1 shall be energised without put potential adjusted to achieve a maximum pipe to soil potential (PSP) as specified, at the test station nearest to the drainage point. Observations on either spread of protected portion of pipeline and coupons under this CP station shall be taken for PSP values at each of the installed test stations (coupon to soil potential at the locations of the coupon installations). The pipeline current values across the cross section of the pipeline shall also be determined at all the intended test stations influenced by this station.

x) CP station no.1 shall now be switched ‘OFF’, CP station no. 3 shall be switched 'ON' and measurement procedure as detailed in clause ix) above shall be repeated.

xi) Similarly CP station no. 1 and 3 shall now be switched 'OFF', CP station no.2 shall be switched 'ON' and measurement procedure as detailed in clause ix) above shall be repeated.

xii) All the CP stations of the system shall be switched 'OFF' and the pipelines shall be allowed to depolarize. All the three CP stations in the system shall then be simultaneously switched 'ON' and PSP values at the drainage points of pipeline shall be brought to a value of maximum PSP as specified and a complete set of observations shall be taken.

Another complete set of pipe to soil and coupon to soil observations shall be taken after lines have stayed on charge for 48 hours. If there are appreciable differences
in these observations as compared to those of earlier set, a third set of observations shall be taken after 72 hours. Maximum drainage point protective potentials shall not be allowed to go beyond the maximum PSP values as specified, in any case.

Coupon to soil 'OFF' potential shall be measured at all locations of coupon installations by operation of magnetic reed switch in the test station. The PSP of the coupons shall be within the PSP range specified in clause 6 of this document. The output of all CP stations shall then be so adjusted that the sites of occurrence of least negative protective potentials are not less negative than (-) 0.95V (OFF) and sites of occurrence of the most negative protective potential are not more negative than (-) 1.18V (OFF). A full set of pipe to soil, coupon to soil observations shall again be taken 72 hours after the adjustment of potentials and the protection system shall be left in this state of operation.

xiii) Care shall be exercised to ensure that power supply remains uninterrupted during the period of commissioning. In case of an interruption, the test in progress shall be repeated after allowing time for polarisation. More sets of observations shall be taken in any of the steps specified above, if advised by the Owner/Owner's representative.

xiv) The zinc anodes for grounding of MOVs at the locations of MOVs on cathodically protected portion of the pipeline shall be reconnected to the MOVs.

xv) At cased crossings where casing is protected, sacrificial anodes provided for the casing shall be connected to the casing pipe. The casing to soil potential and anode output current shall be measured and recorded. Where casing pipe protection is inadequate or the output current of the anode is more than the designed current, then additional anodes shall be provided as required.

xvi) PSP values at each of the test stations of the existing pipelines shall be measured, plotted, where existing pipelines run in parallel to the new pipeline, mutual interference situations between the pipelines shall be identified and necessary mitigation measures shall be provided. Interference situations shall also be identified and mitigated by comparing different sets of readings taken at same test stations at different intervals of time under identical conditions where positive potential swing is 100 mV or more.

xvii) Current readings at all the current measuring test stations shall be measured and recorded.

xviii) Where computerized test stations are provided the computer shall be initialized /started to collect and store the field data of potentials, current readings, etc as programmed.

xix) After one month of starting the computers to collect the field data, the data stored by the computers at all the computerized test stations shall be retrieved/downloaded using the field data-retrieving computer. The data shall be analysed with the help of a station main computer.

xx) At the locations of the Electrical resistance probe installations the resistance readings of the probes shall be measured using probe reader.

xxi) Final records of testing and commissioning including graphical representation of final pipe to soil potential readings shall be compiled with interpretation in consultation with Owner/Owner's representative and submitted.

xxii) If any deficiencies are found in the system, the same shall be rectified by the contractor, at no extra cost or time schedule impact, to the complete satisfaction of
Owner/Owner's representative. Such deficiencies shall include mitigation of stray current electrolysis and interference problems that may be found existing in the course of testing and commissioning. A set of PSP observations shall also be taken during the peak of the first dry season after commissioning the system into regular operation. Any deficiency found in the protection of the pipeline shall be rectified by the contractor at his own cost.

xxiii) If it is found during commissioning that the sites of occurrence of least negative or most negative protective potentials are less negative than (-) 0.95V (OFF) or more negative than (-) 1.18V (OFF) respectively even after 72 hours of operation, then the drainage point potentials shall be adjusted depending upon anode ground bed currents in consultation with Owner/Owner's representative. In any case, the protective 'OFF' potential values of pipeline and polarization coupons shall not exceed the PSP value range specified in cl. 6 of this document, at any location on the pipeline.

xxiv) The reference cell shall be calibrated minimum once in 24 hours during the commissioning.

xxv) The current dissipated by individual anodes shall be measured from the anode lead junction box and corrected for equal dissipation to the extent possible keeping the total ground bed current same.

10.0 INTERFERENCE MITIGATION

10.1 Investigations shall be made for stray current electrolysis of the pipeline, mutual interference between the pipeline and foreign pipelines/structures, interference on foreign pipelines/structures due to the CP of the pipeline and ground bed, interference on metallic structures which lie in between pipeline and ground bed or near to ground bed, AC induction on pipeline due to overhead EHV/HV lines, interference due to high voltage DC lines, HVDC earthing system, electric traction, etc.

10.2 Measurements including pipe/structure to soil potentials and pipe/structure currents etc. on the pipeline/structure being CP protected and on foreign pipelines/structures, and ground potential gradient etc. shall be made to investigate the current discharge and pickup locations. In case of fluctuating stray currents, investigations shall be made continuously over a period of time and if required simultaneously at different locations to find out the stray current source(s). Recorders shall preferably be used for long time measurements.

10.3 Wherever foreign pipelines which may or may not be protected by an independent CP system run in parallel to the protected pipeline, either in the same trench or very near to the protected pipeline and are not bonded to it, investigations shall be performed for current discharge points on both the pipelines.

10.4 Mitigative measures shall be provided depending upon the type of stray current electrolysis/interference. These shall include installation of bond with variable resistor, diodes, installation of galvanic anodes for auxiliary drainage of current, adjustment/relocation (if possible) of offending interference source, provision of electrical shield etc. depending on the type of interference.

10.5 Bonding with foreign pipelines/structures as a mitigation measure shall be provided where the owners of the foreign pipelines/structures have no objection. Otherwise alternative mitigation measures shall be provided. Wherever bonding is provided for mitigation, the bonding resistor shall be adjusted for optimum value for minimum/no interference. Galvanic anodes installed as a mitigation measure shall be adequately sized for the life specified for permanent CP system.
10.6 Where transmission lines cross the pipeline or run in parallel with it or more than 25m from the pipeline, A.C. Voltage measurements shall also be made on the pipeline to find out continuous induction of voltage. In case of the induced voltage being beyond the safe limits, the pipeline shall be grounded to the nearest transmission tower earth system through polarisation cell or to a separate earthing system of zinc anodes of minimum 20 kg net each through polarisation cell.

11.0 CLOSE INTERVAL POTENTIAL SURVEY

Where specified, contractor shall carry out a close interval 'ON'/"OFF" potential survey over the entire length of pipeline by computerised potential logging method and identify the under protected/over protected area, any major coating damage on the pipeline, after the backfilling has been consolidated sufficiently and CP system has stabilized. Contractor shall provide required mitigation measures and rectify the under/over protected zones, identify if any, the major pipeline coating defects, required to be repaired. During the survey the reference cell shall be calibrated minimum once in 24 hours. Detailed procedures for running this survey shall be submitted for review.

Additional tests for detailed identification of coating defects shall be conducted by the contractor.

12.0 DEVIATIONS

12.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
TECHNICAL SPECIFICATION

FIRE DETECTION AND ALARM SYSTEM
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Abbreviations:

BIS  Bureau of Indian Standards
BASEEFA  British Approvals Service for Electrical Equipment in Flammable Atmosphere
CCE  Chief Controller of Explosives
CFAP  Central Fire Alarm Panel
CMRI  Central Mining Research Institute
CPU  Central Processing Unit
DGFAP  Data Gathering cum Fire Alarm Panel
ERTL  Electronic Regional Test Laboratory
FAT  Factory Acceptance Tests
FDD  Floppy Disk Drive
FM  Factory Mutual
FRP  Fibre Reinforced Plastic
FO  Fibre Optic
GUI  Graphic User Interface
HAB  Hooter acknowledgement box (to mute hooters)
HDD  Hard Disk Drive
ISDN  Integrated Service Digital Network
ITU-T  International Telecommunication Union- (Telecom)
LED  Light Emitting Diode
LPC  Loss Prevention Council
LIFO  Last In First Out
MCP  Manual call point (break glass unit; BGU)
MMI  Man Machine Interface
MR  Material Requisition
Ni-Cd  Nickel Cadmium (battery)
PO  Purchase Order
RF  Radio Frequency
SAT  Site Acceptance Tests
SOE  Sequence Of Event
TAC  Tariff Advisory Committee
UWL  Under Writers Laboratory
UPS  Uninterrupted Power Supply
VRLA  Valve Regulated Lead Acid (battery)
WP  Weather Proof
ZFAP  Zonal Fire Alarm Panel
1.0 SCOPE

1.1 The intent of this specification is to define the functional and design requirements for an Integrated Fire Alarm System for industrial plants and buildings. This specification covers the requirements for selection, design, and engineering, manufacture, testing at vendor's works, supply, installation, testing at site and commissioning of the system.

1.2 The Integrated Fire Alarm System shall be conventional or microprocessor based analog addressable system comprising of MCP, detectors; conventional or microprocessor based Fire Alarm panels, CFAP and associated equipments detailed hereunder and in Project data sheets/ drawings.

2.0 CODES AND STANDARDS

2.1 The system and equipment shall comply with relevant BIS (Bureau of Indian Standards) and other Indian/ International standards, as applicable. In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA/ INFPA or equivalent agency shall be applicable. In case of imported equipment, the standards of the country of origin shall be applicable if these standards are equivalent or more stringent than the applicable Indian standards.

2.2 The equipment shall also conform to the special requirement/ provisions of applicable statutory regulations currently in force in the country.

2.3 In case of any contradiction between various referred standards/ specifications/ data sheets and statutory regulations, the following order of decreasing priority shall govern:

- Statutory regulations
- This specification
- Codes and standards

2.4 The fire alarm system and the components used shall conform to the latest edition of the following and also the other Indian and International Standards as applicable.

- IS-5 Colours for ready Mixed Paint & Enamels.
- IS - 513 Specification for cold rolled low carbon steel sheets and strips
- IS/IEC:60079 Flameproof enclosures for electrical apparatus
- IS - 1646 Code of practice for fire safety of buildings (general): Electrical Installations
- IS - 2175 Specification for heat sensitive fire detectors for use in automatic fire alarm system
- IS - 2189 Code of practice for selection; installation and maintenance of automatic fire detection and alarm system.
- IS - 3034 Code of practice for fire safety of Industrial buildings: Electrical generating and distributing stations
- IS - 3700 Essential ratings and characteristics of semi conducting devices (Applicable parts)
- IS - 3826 Connectors for frequencies below 3 kHz General requirements Part-I and tests
IS/IEC:60079  Code of practice for the use of semi-conductor junction devices (Applicable parts)
IS - 5780  Specification for Intrinsically safe electrical apparatus and circuits
IS - 11360  Specification for smoke detectors for use in automatic electrical fire alarm system.
IS - 12459  Code of practice for fire safety in cable runs
IS - 13346  General requirements for electrical apparatus for explosive gas atmosphere
IS-14154 Part 2  Electrical apparatus with protection of enclosure for use in the presence of combustible dust
NFPA 72 Vol 4  National Fire Alarm code
LPC  Loss prevention council recommendations.
BS - 5839  Specifications for manual call points.
BS-EN 50081-1  EMC (Electromagnetic compatibility test)
BS-EN 50082-1  EMC (Electromagnetic compatibility test)

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of the art technology and a proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply. The spares shall be available ex-stock with the vendor.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and PMC before phasing out the product/ spares to enable the end user to place order for spares and services.

3.4 The vendor shall be responsible for design, engineering and manufacturing of the complete system and equipment to fully meet the intent and requirements of this specification and attached data sheets.

3.5 All equipment and accessories required for completeness of the system, whether specifically mentioned or not but considered essential for satisfactory performance, shall be included as a part of the offered system.

3.6 The system integrator shall coordinate with the manufacturers of various bought-out items associated with the system, as required, and shall freely and readily supply all technical information as and when called for.

3.7 Equipments to be located in hazardous areas shall have test certificates issued by recognized independent test house such as CMRI, ERTL, BASEEFA, UL, FM or equivalent. All indigenous equipment shall conform to Indian standards and shall be certified by Indian testing agencies. All equipment (indigenous & imported) shall also have valid statutory approvals as applicable for the specified location. All indigenous flameproof equipment shall have valid BIS license and marking as required by statutory authority.
4.0 DEFINITIONS

4.1 CFAP

It is a fire alarm panel located in fire station or in disaster management control rooms. It is electronic for conventional and microprocessor based for addressable system. CFAP is designed to gather information from distributed fire alarm panels provided in the plant/buildings and have features such as provision to activate plant-wide sirens, have interface with telephone exchange, plant's public address system etc. It has mimic for geographical display of alarms either on panel or as graphic displays on MMI.

4.2 DGFAP

It is a Microprocessor based fire alarm panel, designed for use with addressable fire alarm system. It has alpha-numerical LCD displays along with LED displays for fire/fault conditions. It also includes loop cards (for field devices), I/O cards for interface with other Purchaser's equipment, exit sign and hooters. It functions as fire alarm panel located centrally to population of fire detectors distributed over an area for optimizing and limiting the loop lengths.

4.3 ZFAP

It is a fire alarm panel for conventional fire alarm system. This has functionality similar to what is provided for DGFAP. This has LEDs for fire/fault annunciations.

4.4 Repeater Panel

It is similar to distributed fire alarm panels (DGFAP/ZFAP) but will not have Zone card/Loop card for field devices. These are provided at manned locations and are configured to acquire information about the fire/fault of selected zones from DGFAP/ZFAP and annunciate.

4.5 Integrated Fire Alarm System

It signifies a comprehensive fire alarm system comprising all the distributed fire alarm panels (DGFAP, ZFAP, repeater panels etc) having integration with CFAP for fire monitoring of total plant/building. It provides audio/visual alarm building/plant-wide having provisions for connectivity with telephone exchange, pager system and public address system. It shall provide interfaces with fire protection system and other systems like pressurization systems, air conditioning etc.

4.6 System Architecture

System architecture is line diagram defining the connectivity of DGFAPs, repeater and CFAP. This also specifies various system requirements such as redundancy, communication protocol, communication hardware, cable requirement, workstation and programming tools.

4.7 Data High Way

This term is meant to define the communication path between DGFAPs, CFAP and other network components in microprocessor based fire alarm system. Physical media for Data highway can be fibre optic (FO) cable or twisted pair copper conductor, screened cable.

4.8 Field Devices
Devices such as detectors, MCP, exit signs, hooters, siren etc. are termed as field devices.

4.9 **HAB**

This term is defined as Hooter Acknowledgement Box. HAB for individual buildings shall be provided at its exit.

4.10 **Hazardous Area**

An area in which an explosive gas/ dust atmosphere is present, or likely to be present in quantities such as to require special protection for the construction, installation and use of electrical apparatus.

5.0 **SYSTEM AND SITE CONDITIONS**

All equipment shall be designed to operate with power supply and site conditions as specified below:

5.1 **Input Power Supply**

5.1.1 Unless stated otherwise, purchaser shall provide one point power supply to each fire alarm panel (ZFAP/DGFAP/CFAP/ repeater panel), details of which are indicated in data sheet. A suitable power distribution to various equipment and sub system shall be included in vendor’s scope.

5.1.2 Power supply for fire alarm panels shall have battery backup as per IS-2189. Battery AH rating shall be determined on the basis of maintaining the system in normal operation for a period of not less than 48 hours (quiescent condition) and successive full load alarm condition of period not less than 30 min after the failure of normal mains supply. The switch over from mains to back up, in the event of mains failure, shall be automatic.

Batteries shall be Ni-Cd type. Suitable and adequately rated battery charger shall be supplied as a part of back up battery system.

(The full load alarm condition is defined as operation of all panel/field audio and visual alarm and the alarm load of 25 percent of total zones besides other normal operation loads.)

5.2 **Site Conditions**

The offered equipment shall be capable of operating continuously and maintaining its guaranteed performance at the site ambient conditions indicated in data sheet.

Unless specified otherwise, fire alarm panels along with associated hardware shall be suitable for installation and operation in a closed building/ room with restricted ventilation. Any specific requirements for air conditioned/ dust free environment, etc. for the panels, if absolutely necessary, shall be clearly highlighted by the vendor in the offer.

6.0 **FIRE ALARM SYSTEM DESCRIPTION**

6.1 **General**

Fire alarm system under this specification is envisaged to provide fire monitoring in industrial plants/ chemical plants/ plant and non-plant buildings. The system shall be designed to detect incipient fires and generate audio/ visual alarm in case of fire.

The system shall consist of automatic fire detectors and manual call point or break glass unit. Automatic fire detectors shall work on the principle of sensing of smoke, heat or
infrared rays. Depending on type of smoke, optical or ionization type detectors shall be used. Detectors shall generally be provided in plant/ non-plant buildings. Manual Call Point shall be provided at exit doors of the buildings and at exit route of industrial plants. Number of detectors and break glass unit shall be decided as per guidelines given in applicable codes and standards.

The plant/ building shall be divided into fire monitoring zones. Detectors and MCP at these buildings and plants shall be connected to DGFAP/ ZFAP. These panels shall continuously monitor the state of these devices. On sensing fire condition, an audio/ visual alarm shall be initiated identifying the zone where fire is detected. Panels shall continuously monitor the health of the cabling and in case of short circuit or open circuit fault alarm shall be actuated. Fire alarm panels shall also have powered outputs for switching on exit signs and hooters as specified in data sheet. Further, panels shall provide required output for interfacing with the Purchaser's systems such as air conditioning system or pressurization system or fire protection systems.

Alarms, if specified, shall be relayed to repeater panel provided in buildings like control rooms/administrative buildings to provide zone wise annunciation. In addition facility shall be provided to actuate siren/ hooter.

For integrated fire alarm system where plant-wide large numbers of fire alarm panels are envisaged, these panels shall be integrated to CFAP, which shall be located in fire station or in administrative control room of the building as per the job requirements. The connectivity shall be achieved using data high way or dedicated cable connection from each fire alarm panel to CFAP. Mimic at CFAP shall be provided for fire/ fault annunciation on geographical location in addition to the text/ LED. If defined, CFAP shall have provision for automatic and manual actuation of plant-wide siren as per operator's choice. Interface with other systems such as telephone exchange/ plant's public address system/Pager system shall be provided for communication required for disaster management.

6.2 Conventional/Addressable fire alarm systems

Fire alarm system shall be conventional fire alarm system or microprocessor based fire alarm system as specified in data sheet. Conventional fire alarm system shall have conventional field equipment and Microprocessor based system shall have addressable type field devices.

6.2.1 Conventional fire alarm system shall generally comprise but not be limited to the following equipment used in conjunction with conventional automatic fire alarm detectors and manual call points as a minimum.

i. CFAP with/ without mimic (as per data sheet)
ii. ZFAPs
iii. Repeater Fire Alarm Panel
iv. Plant-wide Sirens and starters
v. Hooters, exit sign and HAB in buildings
vi. Interface with Purchaser's systems
vii. Any other hardware as required to render system complete
6.2.2 Microprocessor based fire alarm system shall generally comprise but not be limited to the following equipments used in conjunction with addressable automatic detectors and addressable MCP as a minimum.

i. CFAP consisting of computer based graphic workstation and engineering station.

ii. Multi loop DGFAPs

iii. Plant-wide sirens and starters

iv. Hooters, exit sign and HAB in buildings

v. Interface with Purchaser's systems

vi. Dual redundant copper/FO cable data highway complete with dual redundant architecture for communication hardware including communication port, switches, processor and power supply

vii. Any other hardware/Software required for rendering system complete

6.2.3 As specified in data sheet, the system shall be provided with siren/s to be located at a suitable location/s in the plant and it shall be actuated manually and automatically as selected by operator from CFAP/DGFAP located at fire station/other buildings.

7.0 CONVENTIONAL FIRE ALARM SYSTEM

7.1 Design Features

7.1.1 The system shall be modular and shall facilitate future extension/ modification. Panel design and component selections shall be done for future extension up to 100/0 of specified zones or one zone whichever is maximum in each panel. The design of common facility and hardware shall be provided for required future extension of zones.

7.1.2 PCBs shall have watchdog feature for self-diagnostic. Each PCB shall have LED for annunciating card failure. Following self-diagnostic features may be considered as minimum.

i. Open loop detection

ii. Short circuit detection

iii. Earth faults

iv. Power supply failure e.g. low battery voltage, main incoming supply fail

v. System faults (PCB failure)

7.1.3 Logic of operation shall be built on "Fail safe" feature i.e. NC contact of field devices shall be considered as healthy condition and NO as fire condition. 1NO+1NC contact of output relays shall be wired to terminal block for interface with Purchaser's other equipment.

7.1.4 It shall be possible to test lamps, hooters, flasher circuit, and functional tests etc through common "Test" push button.

7.1.5 The circuit shall be so designed that silencing of the current alarm by ACCEPT push button shall not prevent annunciation of subsequent fire alarm received from any other location

7.1.6 Signal-to noise ratio shall be high to avoid spurious actuation due to noise induced in the field wiring because of proximity with power cables. Cables for field devices shall be
multicore copper conductor, unscreened, armoured, copper conductor cable. If required noise filters shall be provided at fire alarm panel.

7.1.7 Detectors and MCPs in a loop shall be wired through 1.5 mm² multi-core, Copper conductors, PVC insulated, armoured cable. Limiting distance from fire alarm panel to last detector/MCP shall not be less than 2 km or as specified in data sheet whichever is maximum.

7.1.8 LEDs shall be provided for fire/ fault visual annunciation on the panel front. LED shall also be provided for Power supply healthy, Battery backup ON, Battery/ Charger status.

7.1.9 If zone is protected with clean agent/ CO2 system, the detectors and MCPs of the zone shall be wired in cross-zones by providing minimum two loops in a zone. The last device in each loop shall be provided with end of line resistor of suitable value as per circuit design to facilitate cable open circuit and short circuit detection.

7.1.10 Scheme for FIRE/ FAULT annunciation shall be as per the following.

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<tr>
<th>SYSTEM CONDITION</th>
<th>AUDIO</th>
<th>VISUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORMAL</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>FIRE</td>
<td>ON (tone 1) Flasher ON, Fire LED Steady ON</td>
<td></td>
</tr>
<tr>
<td>Accept</td>
<td>OFF</td>
<td>Flasher steady, Fire LED steady ON</td>
</tr>
<tr>
<td>Reset</td>
<td>OFF</td>
<td>Flasher OFF, Fault LED OFF</td>
</tr>
<tr>
<td>FAULT</td>
<td>ON (tone 2) Flasher OFF, Fault LED Steady ON</td>
<td></td>
</tr>
<tr>
<td>Accept</td>
<td>OFF</td>
<td>Flasher OFF, Fault LED Steady ON</td>
</tr>
<tr>
<td>Reset</td>
<td>OFF</td>
<td>Flasher OFF, Fault LED OFF</td>
</tr>
</tbody>
</table>

7.1.11 Fire alarm panels including repeater panels and CFAP shall be certified/ approved by applicable approving agency of country of origin as required.

7.2 Zonal Fire Alarm Panel

7.2.1 ZFAP shall consist number of zones as specified in data sheet. Detectors/MCP/ heat sensing cables etc shall be connected zone wise in a loop. It shall monitor fire/ fault condition of the zone. ZFAP shall be located indoor in safe area.

7.2.2 ZFAP shall be free- standing, floor mounting vertical panel consisting of audio/visual annunciation with Alarm Accept; Test and Reset Push Buttons, Auto/Manual control of hooters provided in buildings. Provision to actuate siren shall be provided if specified in data sheet. Circuit shall be designed to provide annunciation if any detector in a zone senses fire. Annunciation scheme shall be as per clause 7.1.10

7.2.3 Audio/ Visual indication and annunciation shall be as per clause 7.1.8.

7.2.4 ZFAP shall have required interface hardware where integration with CFAP/ repeater panel is envisaged as per data sheet.

7.2.5 Output contacts (1NO+ 1NC) shall be provided for interface with Purchaser's systems as per clause 9 of this specification. The rating of output contact shall be 0.5A, 220V DC or 2A, 240V AC.

7.2.6 Input power supply and battery backup for ZFAP shall be as per data sheet and as per clause 5.1 of this specification.
7.3 Repeat Alarm Panel-Conventional

7.3.1 Repeat fire alarm panel shall be similar to ZFAP except providing zones for detector loops. Fire/ fault annunciation of ZFAP shall be repeated to repeater panel. Annunciation scheme shall be as per 7.1.10 Depending on the size Repeat Fire Alarm panel may be floor mounting type or wall mounting type.

7.3.2 Where required, input power supply from purchaser shall either be 240V or 110V, 1 phase, 50Hz. It shall be possible to select supply either 240V or 110V at site without modifying or adding additional equipment in the panel.

7.4 Central Fire Alarm Panel

7.4.1 CFAP shall be located in fire station in plants or in building control room. Fire and fault annunciation for each Zone or group of zones at ZFAP shall be repeated at CFAP. Annunciation scheme at CFAP shall be provided as per the clause 7.1.10.

7.4.2 CFAP shall be in vertical panel construction or desk type construction having controls such as Accept, Test and Reset Push Buttons, Auto/Manual control of siren etc.

7.4.3 Unless otherwise specified in the data sheet, CFAP shall have mimic to display geographical location of fire. Mimic shall form an integral part of the CFAP and shall be located at the top of the panel. When separate mimic panel is specified, it shall either be wall mounting or freestanding floor mounted type. Two LEDs shall be provided for each zone on mimic panel for display of fire alarm. Mimic panel shall be powered by CFAP. Mimic made out of plastic stickers shall not be acceptable.

7.4.4 Input supply and battery backup for CFAP and MIMIC shall be as per data sheet and as per clause 5.1 of this specification.

8.0 MICROPROCESSOR BASED FIRE ALARM SYSTEM

8.1 Design Feature

8.1.1 Unless otherwise specified Microprocessor based system shall be analog addressable type. The system shall be integrated as per 'system architecture' indicated in data sheets.

8.1.2 Microprocessor based fire alarm system shall be designed to use state of the art technology. All fire alarm panels including repeater panel shall be networked through data high way. The system supplied shall not pose any limitation for future expansion by way of networking of fire alarm panels, data transfer, parameterization of addressable field devices, graphic displays etc.

8.1.3 The system shall be modular and shall facilitate future extension/ modification. Panel design and component selections shall be done for future extension up to 10% of specified zones or one zone whichever is maximum in each panel. The design of common facility and hardware shall be provided for required future extension of zones.

8.1.4 PCBs shall have watchdog feature for self-diagnostic. Each PCB shall have LED for annunciating card failure. Following self-diagnostic features may be considered as minimum.

i. Open loop detection

ii. Short circuit detection

iii. Earth faults

iv. Power supply failure e.g. low battery voltage, main incoming supply fail
8.1.5 Unless specified otherwise in data sheet, system architecture shall have minimum redundancy indicated below however not limited to the same.

i. Dual redundant at processor level (communication processor and I/O card processor)

ii. Dual redundant communication port

iii. Dual redundant data highway cable

iv. Dual redundant microprocessor at CFAP

v. Dual redundant work station/MMI (engineering station+ operator’s station)

vi. Dual redundant power supply card at all fire alarm panels (but with single source of battery backup)

8.1.6 Data highway shall be Fibre optic or twisted pair shielded copper cable as specified in data sheets. Whether specified or not, data highway shall include all necessary hardware such as modem, repeaters, network switches/ hubs etc including power supply system as required to suit the length of data highway.

8.1.7 The communication shall be peer to peer between various OGFAPs, repeater Panels, CFAP and other system components connected on fire alarm system data highway.

8.1.8 Any fault in Analog detector addressable loop and data highway shall not impair communication i.e. Communication/ flow of analog signal shall be possible from either end of the loop.

8.1.9 The loop cabling for wiring detectors and MCPs shall be class A, fault tolerant type as per NFPA 72.

8.1.10 Fire alarm logic shall be programmable type. The logic for zone protected with clean agent system/ CO₂, shall be programmed to provide output for actuation after ensuring that there is no false alarm. Similarly logic to switch ON the exit sign and sound the hooters shall be programmable type.

8.1.11 The logic shall be so programmed that silencing of the current alarm by ACCEPT push button shall not prevent annunciation of subsequent fire alarm received from any other location.

8.1.12 Signal-to noise ratio shall be high to avoid spurious actuation due to noise induced in the field wiring because of proximity with power cables. Unless otherwise specified, fire alarm cables laid in buildings shall be twisted pair, screened and unarmoured and shall be laid in conduits while cable laid outdoor in plant shall be twisted pair, screened and armoured. If required noise filters shall be provided at fire alarm panel.

8.1.13 Unless otherwise specified in data sheet, the minimum number of detectors/ MCP/ addressable devices in a signal loop shall be 60.

8.1.14 Unless otherwise specified in data sheet, conductor size of loop cable shall be 1.5 sqmm copper. The allowable signal loop length shall not be less than 2 km. To optimize length, circuit design for loop shall allow the use of spur connection.

8.1.15 DGFAP and repeater panel shall have backlit alphanumeric LCD display to provide addresses, status of each field device. In addition LEOs shall be provided for fire/ fault
visual annunciation. LED shall also be provided for Power supply healthy, Battery backup ON, Battery/Charger status.

8.1.16 Fire station shall be provided with dual redundant PC with monitor for operator's workstation and for engineering station. Any of the two should be possible to configure as engineering station for programming offline. After Programming, the engineering station will be connected to network as online operator's workstation. Programming shall also allow activating Siren from the keyboard in manual mode as per operator's choice.

8.1.17 Scheme for FIRE/FAULT annunciation shall be as per the following.

<table>
<thead>
<tr>
<th>SYSTEM CONDITION</th>
<th>AUDIO</th>
<th>VISUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORMAL</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>FIRE</td>
<td>ON (tone 1)</td>
<td>Flasher ON, Fire LED Steady ON</td>
</tr>
<tr>
<td>Accept</td>
<td>OFF</td>
<td>Flasher steady, Fire LED steady ON</td>
</tr>
<tr>
<td>Reset</td>
<td>OFF</td>
<td>Flasher OFF, Fault LED OFF</td>
</tr>
<tr>
<td>FAULT</td>
<td>ON (tone 2)</td>
<td>Flasher OFF, Fault LED Steady ON</td>
</tr>
<tr>
<td>Accept</td>
<td>OFF</td>
<td>Flasher OFF, Fault LED Steady ON</td>
</tr>
<tr>
<td>Reset</td>
<td>OFF</td>
<td>Flasher OFF, Fault LED OFF</td>
</tr>
</tbody>
</table>

8.1.18 All field devices such as detectors and MCPs shall be addressable type. If available in vendor's design, hooters and exit sign may also be connected in addressable loop. Fault isolators shall be provided to minimize outage of number of detectors/MCPs in case of loop cable fault. For hazardous area flame proof equipment shall be used. As far as possible, the use of intrinsically safe field devices in hazardous area should be avoided. If unavoidable, due care shall be taken care in design to avoid signal distortion and thus the mal-operation due to cable capacitance and inductance.

8.1.19 System shall provide adequate EEPROM size to store minimum of 10 events fire/fault. The event shall be stored in LIFO structure. All events shall be time stamped. DGFAP shall have real time clock for event time stamping.

8.1.20 Software access for either Zone programming or access to plant/building graphic on monitor shall be password protected. For viewing status of various field devices e.g. fire and fault status password protection shall not be given.

8.1.21 Fire alarm panels including repeater panels and CFAP shall be certified/approved by an international approving agency/approving agency of country of origin as applicable.

8.2 Data Gathering Cum Fire Alarm Panel (DGFAP)

8.2.1 DGFAP shall have basic design features as per clause 8.1 above. Number of signal loops in each DGFAP shall be as defined in the data sheet. Number of loops shall be basic part of main PCB and should not be extended by providing external electronic devices. LCD display and annunciation scheme shall be as per clause 8.1.17.

8.2.2 It shall be possible to change the reference value of detector sensitivity either manually or automatically as required during the operation to avoid false alarms prior to detector maintenance.

8.2.3 DGFAP shall have serial port for communication to data highway. It should be possible to communicate all the information to CFAP/FA system workstation located with fire marshal. The protocol of communication shall preferably be open protocol.
8.2.4 In the event of non-availability of data highway, DGFAP shall work as stand alone intelligent panel monitoring fire in the zones connected to it.

8.2.5 It shall be possible to configure DGFAP to access data of any other DGFAP and display as per the operation requirement to be finalized during engineering/ commissioning.

8.2.6 It shall be possible to interface with existing fire alarm system consisting of conventional zone detectors and MCPs with end of line resistor as a part of retrofitting.

8.2.7 DGFAPs shall have output relays to provide interface with Purchaser's system defined in clause 9 as minimum.

8.3 Repeat Alarm Panel

8.3.1 These panels shall be required for repeat of alarm in building/ plant control rooms. These panels shall be similar to DGFAP and shall be connected to data highway through serial communication. Panels shall have programming facility to inhibit the display of information that is not required in a particular repeater panel.

8.4 CFAP/ PC based monitoring station or Work station

Based on vendor's system design CFAP shall include network PC based monitoring station directly connected to data highway with other peripherals such as network switches/ controller (HUB). Alternatively, vendor may supply CFAP similar to DGFAP along with PC based monitoring station. Application software shall be installed in PC as GUI. The graphic shall include geographical location of various plant areas including location of addressable detectors and MCPs. The navigation between various graphic pages shall be user friendly. The screen shall have defined area to display the latest fire or fault alarm and shall also have facility to pop up the graphic displaying the location of fire event.

8.4.2 Unless stated otherwise, CFAP shall have all the features and facilities of the DGFAPs. It shall monitor the status of each addressable field device indirectly from the DGFAPs connected on data highway.

8.4.3 Engineering workstation shall be used for programming off-line. After programming, the changed parameters shall be downloaded to other PC to work in synchronism as normal operation. This station shall also have two printers connected to PCs working as SOE printer and engineering printer. SOE printer shall be high-speed dot matrix printer and engineering printer shall be laser printer.

8.4.4 Unless specified otherwise, adequately rated UPS with bypass shall be provided for PC based monitoring station. Battery backup shall be sized as per criteria given under 5.1. Only normal supply shall be made available at one point by Purchaser at the location of central fire alarm panel.

8.4.5 It shall be possible to actuate plant-wide siren in auto/ manual mode. Unless otherwise specified, manual actuation shall be done from keyboard of workstation. Auto actuation shall be through software logic, which shall be finalized with end user during implementation. Auto/Manual selection shall be provided at operator's workstation. The actuation signal under manual mode selection shall be communicated serially to DGFAP to which siren starter is connected. Siren starters shall be hardwired to DGFAP.

8.4.6 The minimum requirements for the PC and other peripherals shall be as stated below:

* Industrial type Latest generation PC Intel Core i7, 7th Generation

* 4MB ( Min.) Cache memory.

* 8 GB RAM. ( Min.)
Application software supporting graphics with no limitation on number of graphics, events, alarms, number of field devices as required for any large plant like refinery, petrochemical complex or the large multistory building.

8.4.7 It shall be possible to provide multilevel access of fire alarm system. Read only access shall not require password protection. Access for programming and access for controls from keyboard shall be password protected. The levels of password protection shall be agreed with plant operators at the time of commissioning of system.

8.4.8 Printer

i. Printer options shall include both graphic laser printer and dot-matrix event text printer.

ii. Printer used in the system shall provide real time records of the system events and provide system reports on demand, and shall be microprocessor controlled, high speed, read only (RO) letter quality dot-matrix type 132 characters wide and 96 character set.

9.0 INTEGRATION WITH VARIOUS PLANT SYSTEMS

9.1 Fire Alarm System shall have required hardware to have interface with following plant systems as specified in data sheet.

i. Public Alarm Announcement system

ii. Paging and plant intercom systems.

iii. Plant data network

iv. ISDN telephone exchange and pager system

v. Fire suppression system

9.2 ZFAP as a minimum shall be provided with the following interface with fire suppression system unless specified otherwise.

i. Automatic signal for release of clean agent/CO₂, release for protected area and RELEASE audio/Visual alarm for evacuation.

ii. Selector switches for primary or secondary clean agent/CO₂ supply for each protected area.

iii. Manual push button for discharge of clean agent/CO₂, in each protected area. The actual release of clean agent/CO₂ shall however be delayed by 30 sec after the alarm.
iv. Clean agent/CO₂ Discharge inhibit push button for each protected area.

v. Deluge valve activation push buttons, deluge valve test push buttons and deluge valve activated status lamps.

vi. Shutdown signals to various air-handling units relative to the zone of fire.

vii. Firewater pumps start push buttons.

viii. Firewater pumps running indications.

10.0 PANEL CONSTRUCTION (CFAP, DGFAP, ZFAP, REPEATER)

10.1 All fire alarm Panels shall be free standing, floor mounting type unless specified otherwise and shall be fabricated out of minimum 2mm thick CRCA sheets and doors shall be fabricated out of minimum 1.6mm CRCA sheets. The panel shall be naturally ventilated in IP-41 enclosure protection as minimum.

10.2 Equipment Mounting

10.2.1 All apparatus, display screen, instruments and indicating lamps mounted on the panel front shall be flush mounting type. The external cabling shall not be terminated directly on the base connector of PCBs but shall be terminated on separate terminal block. Further connection to PCBs shall be as per manufacturer's standard. Routine calibration, adjustments, programming and operation shall be accessible from the front of the panel without opening the door. External cabling shall preferably be done from the rear.

10.2.2 Power supply system including battery bank shall be mounted inside the panel.

10.2.3 Doors shall be provided with pistol grip handle with lock. Lamps shall be provided inside the panel to provide adequate light for maintenance of equipments.

10.2.4 Cable entry shall be from bottom unless otherwise specified in the data sheet. Terminal strip shall be provided for incoming / outgoing cables.

10.3 Wiring and Terminals

10.3.1 Wiring within the panel shall be laid in slotted plastic raceways enclosed with cover. Control connections shall be done with 660V grade PVC insulated wires having stranded copper conductors. 1.5mm² size of wire shall normally be used for circuits with control fuse rating of IOA or less. Control wiring for electronic circuits shall be through ribbon cable or through copper wire minimum of 0.5mm dia. Panels shall be supplied completely pre-wired, such that only field termination shall be required at site before it is energized.

10.3.2 PCBs for identical functions shall be interchangeable. PCBs shall be plug in type having pin/edge connectors. PCBs shall be suitable for use in tropical, humid and dusty environment. These shall be protected with anti fungus treatment.

10.3.3 Cables shall be terminated on terminal blocks. Clamp type terminals shall be of spring-loaded, stacking type, mounted on rails. Terminals shall be sized to accept, as a minimum 2.5mm² cross section conductors. Not more than one conductor shall be terminated on the outgoing side of each terminal. At least 20 % spare terminals shall be provided in each panel for termination of spare cores of cables.

10.4 Earthing

10.4.1 A common earth bar of minimum 25 x 3 mm. copper or equivalent aluminium shall be provided throughout the length of the panel. All non-current carrying metallic parts of the panel mounted equipment shall be earthed. Flexible jumpers shall connect all doors and
movable parts to the earth bus. Two numbers earth lugs shall be provided outside the panel.

10.5 **Name Plates / Warning plates**

10.5.1 All nameplates for panel shall be engraved out of 3 ply (black-white-black) lamicoid sheets or anodized aluminum. Back-engraved Perspex sheet nameplates will also be acceptable. Engraving shall be done with square groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable.

10.5.2 Labels shall be provided for every component on the cards, connecting wires as well as for the terminals in the terminal strip inside the panel. Wiring diagram shall be pasted inside the panel door as required for termination and maintenance.

10.5.3 Special warning plates shall be provided on all removable covers or doors giving access to energized metallic parts above 24 volts.

10.6 **Painting**

10.6.1 All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The undersurface shall be made free from all imperfections before undertaking the finishing coat.

10.6.2 After preparation of the undersurface, the panel shall be powder coated. The colour shade of final paint shall be as approved by the purchaser. The finished panels shall be dried in dust free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, fun-off paint etc.

10.6.3 All unpainted steel parts shall be cadmium plated or suitably treated to prevent rust-corrosion. Moving elements shall be greased.

11.0 **CABLE AND CABLE ACCESSORIES**

11.1 Unless otherwise specified, purchaser shall supply and lay only the following cables.

i. Signal Loop/ Zone Cables from outdoor field devices to the fire alarm panel except for buildings.

ii. Loop/ Zone cables from FA panel to JB (Vendor shall provide JBs in each building for signal loop cabling. Cables from J8 to fire alarm panel is included in purchaser's scope while cable from JB to detectors and all other field devices shall be included in vendor's scope.)

iii. Exit sign and hooter cables from FA panel to JB (Vendor shall provide separate JB for exit sign and hooter. Cables from JB to fire alarm panel is included in Purchaser's scope while J8 to exit sign and hooter is included in vendor's scope.)

iv. Cable from purchaser's switchgear to siren starter and siren starter to siren.

v. All interface cables from fire alarm panels to purchaser's system.

vi. Incoming power supply cables from purchaser's switchgear to Fire Alarm Panels All other cables as required for fire alarm system including the supply, laying and termination of cables and accessories within buildings from JBs to detectors/ MCPs, exist signs, hooters and also supply, laying, termination of data high way cables, high way accessories etc as required for successful commissioning shall be in vendor's scope.
Though the supply and installation of field cabling is excluded from vendor's scope but terminations of all cables (supplied by both vendor/purchaser) at both ends shall be in vendor's scope.

Bidder, as a part of integration and selection of fire alarm equipment, shall furnish detailed specifications for loop/zone cables, data highway cables, cables for hooter/exit signs etc giving details such as type of cables, number of pairs, size of cable, inductance and capacitance data, number of fibres/ connectors etc.

Data Highway Cables

Unless specified otherwise, vendor shall supply Copper cable/ FO type data highway cable to suit system design and equipment specification. Copper cables, if supplied, shall be of adequate size, twisted pair, PVC insulated, overall screened, PVC inner sheathed, armoured, FR type PVC outer sheathed as the minimum requirement. Fibre Optic cables, if supplied, shall be armoured, overall FR PVC outer sheathed and shall be as per ITU-T recommendation as a minimum.

Vendor shall supply and install all hardware and cabling accessories as per data highway design including modems, repeaters etc as part of the FA system. Modems/repeaters shall be powered by the supply provided for DGFAPs / CFAP.

Cable Glands / Accessories

All cable glands/ lugs/ connectors as required for the equipment shall be included in vendor's scope and shall be supplied along with the system, irrespective of whether installation is to be performed by vendor or not.

All the cable glands for outdoor application shall be weatherproof, nickel-plated brass and double compression type, whereas those for indoor application shall be single compression type.

Cable glands for hazardous area equipments shall be flameproof, weatherproof and nickel plated brass double compression type.

AUTOMATIC FIRE DETECTORS AND ACCESSORIES

General Specifications

Detectors for conventional fire alarm system shall be conventional type. End of line resistor shall be provided at the last detector in the zone. Detectors for microprocessor shall be addressable type. Detectors shall be plug-in type and shall have twist lock action fitting. Multicolour LEOs provided on the detectors shall indicate Normal and Alarm state. Essential features of detectors are indicated as below.

Detectors shall be supplied with mounting bases. Mounting base shall be identical for all type of detectors except special application detectors such as linear beam detectors etc. for installation as well as cable connection. Detector housing (body and cover) shall be made up of damage resistant, fire resistant polycarbonate and shall be suitable for either surface or recess mounting. Detector base shall be mounted on Junction boxes having terminals for cable termination. Where installation is included in vendor's scope, equipment such as GI conduits, GI junction box/ conduit box etc. shall also be included in vendor's scope.

Detectors shall be suitable for storage at ambient condition specified in data sheet.
12.1.4 Detectors, which employ Radio Active source, shall be such that the strength of the Radio Active material shall not exceed 1 micro curie or as per latest standard whichever is less.

12.1.5 All detectors shall be on the approved list of LPC, UL / FM/ equivalent international approving agency as applicable.

12.1.6 All detectors shall be suitable for operation at DC power supply extended from fire alarm panel.

12.1.7 The addressable detectors shall be continuously monitored to measure changes in their sensitivity due to the environment (dirt, dust, temperature, humidity etc.). These detectors shall give an advance indication to the panel regarding the need for maintenance. The analogue reading sent by the detectors shall be sensed and if there is a rapid increase, an alarm shall be generated. However, if there is a gradual increase in the analogue reading, a maintenance alert shall be generated by the fire alarm panel. It shall be possible to generate maintenance reports from the fire alarm panel. For the addressable detectors two-wire operation shall be possible.

12.1.8 All addressable detectors shall have selectable settings for pre-alarm and alarm and preferably have the facility to set the sensitivity and address from the fire alarm panel.

12.1.9 Manual call points / break glass boxes for microprocessor based fire alarm system shall be addressable type. Each device shall have its own address module.

12.1.10 All addressable detectors shall be suitable for installation using fault tolerant wiring (class-A, style - 6 wiring as per NFPA72). T-Tapping shall not be permitted in the case of such wiring.

12.1.11 All detectors must have insect screen to prevent entry and cause false alarm.

12.1.12 All field devices shall be from the latest generation in the manufacturer's range of products. Commonly used field devices are listed below. The specification given shall be considered as the minimum requirements.

12.2 Heat Detectors

12.2.1 Heat detectors shall use negative temperature coefficient thermisters for sensing and for reference. The detector shall be designed to give a response that depends on both absolute temperature and rate of rise in temperature.

12.2.2 The rate of rise element shall be carefully calibrated to ignore any normal fluctuation in temperature, but to respond quickly when the temperature rise is 9°C or more per minute.

12.2.3 The fixed temperature feature should be entirely independent of the rate of rise element. The operating temperature of fixed temperature element should be factory set at 57°C ± 5°C.

12.2.4 The detector shall be self-restoring type ensuring repeated use and easy maintenance.

12.3 Ionization Smoke Detector

12.3.1 Ionization smoke detector shall be solid-state type, working on ionization principle and shall preferably be of dual chamber and dual source type.

12.3.2 The detector shall be able to sense incipient fire by detecting the presence of visible and invisible products of combustion like wood, paper, ammonia processing paper, cloth, PVC, bakelite, nylon, foam, acrylic, thermocol, Photo film, nylon, polyester, painted sheets, Teflon, leather etc.
12.3.3 The sensitivity of the detector shall not vary with change in ambient temperature, humidity, pressure or permissible voltage variation. Its performance shall not be affected by an air current of 5 m/sec. It shall have an inbuilt arrangement such that puffs of smoke or hot air pockets do not inadvertently trigger the alarm. The detector shall be protected against dust accumulation/ ingress. It shall have insect resistant screen to prevent nuisance alarms.

12.3.4 Where air velocity is expected to be higher, smoke guard/ baffle shall be used.

12.3.5 Where specified, smoke detectors operating on laser diode principle shall be offered.

12.4 Photo Electric / Optical Smoke Detector

Photo electric/ optical smoke detectors shall work on the principle of light scattering utilizing a light emitting diode.

12.5 UV Flame Detectors

12.5.1 UV flame detectors shall work on the principle of a vacuum photodiode tube to detect the UV radiation that is produced by a flame.

12.5.2 UV flame detectors shall respond to ultraviolet rays of a flame. The detector shall not be actuated by artificial lights, sunlight incident through a windowpane or welding arc. False alarm check circuit shall be incorporated to prevent false alarm due to intermittent flash or lightning.

12.6 IR Detectors

12.6.1 IR detectors shall work on the principle of single wavelength infrared flame detector using one of several different photocell types to detect the infrared emissions in a single wave length band that are produced by a flame.

12.6.2 IR detectors shall react to the infrared rays of a flame. It should be sensitive enough to detect smoky fires in which flame is hardly recognizable. The detector should not react to extremely glaring artificial light or direct sunlight. The detector shall be completely solid-state type.

12.6.3 Where specified combination UV-IR detector shall be used.

12.7 Linear Beam Detector

12.7.1 Linear beam detector shall work on the principle of obscuration of infrared light beam by particles of smoke. The sensitivity shall be such as to enable operation at 30% to 500% obscuration.

12.7.2 Linear beam detector shall consist of separate transmitter and receiver. Linear beam detector shall be suitable for application in high roofed locations such as warehouses etc. The detector shall, preferably, be powered from the loop signal itself. However, if external power supply is required the same shall be explicitly stated by the vendor, which shall be covered under common power supply for the fire alarm panel and devices connected with it.

12.8 Heat Sensing Cables

12.8.1 Heat sensing cable shall be analogue type. It shall consist of four copper conductors, each covered with a colour coded, negative temperature co-efficient material. The cores shall be twisted together and protected by an outer sheath of high temperature, flame retardant PVC insulation. External mechanical protection shall be provided over the
sensor cables. Vendor shall provide control unit for each 100 m length of the sensor cable.

12.9 **Manual Call Point (MCP)/ Break Glass Unit (BGU)**

12.9.1 Manual break glass unit shall be fabricated out of 14-gauge cold rolled sheet steel. Alternately the break glass unit may be made of die cast aluminum alloy such as LM6. It shall have IP-55 enclosure and weatherproof construction suitable for outdoor installation. The break glass unit shall have a minimum dimension of 100x100x80mm.

12.9.2 The box shall be fabricated in such a way it can be mounted flush to the wall or on the surface without any modification. Two nos. 19 mm knockouts shall be provided at the bottom of the box to facilitate cable / conduit entry. The glass shall cover at least 30cm² area and shall have a thickness not exceeding 2mm.

12.9.3 The box shall have a push button element kept in pressed condition by a glass sheet fitted in the front of the box.

12.9.4 The enclosure shall be painted with fire red colour (shade 536 of IS-5) epoxy painting and an inscription" Break Glass in case of Fire", shall be painted in white letters or riveted on the enclosure by a steel nameplate. A suitable nickel-plated brass hammer, duly chained to the box with stainless steel chain shall be provided with each box for breaking the glass. Each box shall have a distinct identification number boldly painted on it.

12.9.5 If specified in the data sheet, the BGU shall have a suitably wired telephone hand set to facilitate communication between the BGU and the central annunciation panel. Telephone hand set mounted on hook switch shall be housed in a separate lockable weatherproof break glass window enclosure. The glass will be broken in case of fire with the hammer provided with the BGU.

12.9.6 Hazardous area Break Glass Units shall meet the requirement of clause 13 of this specification.

12.10 **Response Indicator**

12.10.1 If specified in the data sheet, response indicators shall be provided suitable for wall/ceiling mounting. Response indicator shall be provided where the detector is located either above false ceiling or below false floor or where detectors are not directly visible. The response indicators shall be connected to the detectors directly and shall be complete with terminal blocks suitable to accept cables with up to 1.5mm² copper conductor. In the normal state of detector, the LEO shall flicker, but in the event the detector goes into alarm condition, the LEO shall glow steadily. LEOs shall be red in colour with 5mm dia. as a minimum.

12.10.2 Use of Response indicators in addressable system is not envisaged unless otherwise specified in data sheet.

12.11 **Exit Signs**

12.11.1 Exit signs shall be fabricated out of 1.6mm thick cold rolled sheet steel. This shall be suitable for wall mounting or suspension from ceiling. Exit signs suspended from the ceiling shall have text/ direction printed on both the side of exit sign.

12.11.2 Fire exit shall be displayed by means of 5mm dia LEOs or backlit text. It shall be powered from the fire alarm panel. Exit sign shall operate on DC power supply 12.11.3. The exit sign shall be either in red letters on white background or white letters on green background.
12.11.4 Where specified in data sheet, self-luminous exit sign shall be provided.

12.12 **Hooters**

12.12.1 The unit shall consist of solid-state circuitry on a printed circuit board, a loudspeaker and a flashing lamp housed in a weatherproof dust tight, wall mounting type enclosure. The hooter shall, at least, have 102 db (A) output measured at 1-meter distance. The unit shall be powered from the fire alarm panel and operate on DC power. In the event of fire, the hooter shall raise pulsating audio alarm and the lamp shall start flashing.

12.12.2 HAB shall be provided at exit doors of buildings to mute the hooters after evacuation.

12.13 **Flashing Lights (Beacon)**

12.13.1 The unit shall consist of solid-state circuitry on a printed circuit board and a red-capped incandescent lamp and audio unit housed in a dust tight, wall/ ceiling mounting type enclosure. It shall derive power from the DGFAPI ZFAP and shall operate on DC supply.

12.13.2 Flashing lights shall be installed in the enclosed areas where clean agent/ CO₂ is to be released.

In the event a signal for clean agent/CO₂, release is given, the lamp shall start blinking with a warning sound enabling operating personnel to evacuate the area. The audio unit (hooter) shall have 102 db (A) output measured at 1-meter distance.

12.14 **Clean Agent / CO₂ Release and Inhibit Switches**

12.14.1 This unit is required to be provided at the exit of the protected buildings/ rooms. If specified, this unit is integrated with DGFAPI ZFAP. This shall consist of pull type release and inhibit switches clean agent / CO₂. The unit shall be fabricated out of 2mm thick cold rolled sheet steel suitable for wall mounting. Switches shall be pulled to release or inhibit clean agent / CO₂. Release switches shall have inscription:

"PULL TO RELEASE CLEAN AGENT / CO₂"

And inhibit switches shall have inscription:

"PULL TO INHIBIT CLEAN AGENT / CO₂"

12.15 **Zener Barrier**

12.15.1 Preferably flameproof (Ex'd') equipment that does not require the use of Zener barrier shall be used. When necessary, intrinsically safe (Ex 'i') detectors and MCPs, Zener barriers shall be provided. These shall be located in unclassified/ non-hazardous areas.

12.15.2 Normally not more than 10 detectors shall be connected to one zener barrier. However vendor shall indicate maximum number of detectors MCPs that can be connected to one Zener barrier without compromising on working of loopl zone. Vendor shall also indicate the maximum loop length from zener barrier considering 1.5 mm² copper conductor, screened cable.

12.15.3 In case loop length permits, zener barrier shall be located at DGFAP itself else it shall be located in safe area nearest to the detector/ MCP.

12.15.4 Wherever zener barriers are provided in safe area outside the Zonal panel or DGFAP, these shall be housed in their own enclosure with IP-55 degree of protection as a minimum.

12.16 **Fault Isolator**
12.16.1 Fault isolator shall be installed, if specified in the data sheet.

12.16.2 Fault isolator shall be designed to provide short circuit protection to an addressable detector loop. It shall be possible to wire the fault isolator at any point in the detector loop.

12.16.3 On occurrence of a fault (short circuit), the isolator shall cut power to all devices installed between the two isolators minimizing the outage of all the detectors in a loop.

12.16.4 The fault isolator shall have the capability to continuously check the faulted side of the loop to determine if the fault still exists. On rectification of the fault, the isolator shall automatically reset itself.

12.16.5 Fault isolator modules shall be housed in an enclosure having IP-55 degree of protection as a minimum. If located in hazardous area, it shall also be tested and approved for use in area classification defined in the data sheet.

12.17 Sirens

12.17.1 Sirens shall be industrial type with minimum 2.5 km unidirectional range (i.e. 5km diametrical range) against the wind direction.

12.17.2 The decibel level of the siren shall, at least be 132 db(A) at 1 meter, to meet the audibility requirement for the above range. Unless otherwise specified, Sirens shall operate at 415 V, 3 ph. AC supply. Sirens shall be housed in weatherproof enclosure. Starter shall be DOL and shall be housed in a separate IP55 enclosure suitable for installation indoor/ outdoor.

12.17.3 For three-phase siren, wall-mounting type three-phase DOL starter shall be supplied. Starter shall be mounted indoor in a building where siren is located. The supply to the siren starter shall be provided by purchaser from Normal or Emergency power source as defined in the data sheet.

13.0 FIELD DEVICES FOR HAZARDOUS AREA

13.1 Hazardous area is classified as Zone 1/ Zone 2, gas group IIA/ IIB or IIC, temperature class T3 (200 DC) as specified in data sheet. The field devices shall be suitable for installation in hazardous area as per specified area classification.

13.2 Field devices such as detectors, MCPs, fault isolators, Beacons, hooters etc for use in hazardous area, if specified in the data sheet shall have flame proof enclosure conforming to IS 2148. All equipment for hazardous area installation shall be complete with flame proof, weather proof cable glands as specified in clause 11.5.

13.3 Equipment, which cannot have flameproof construction, shall be intrinsically safe in design and shall be used with Zener barriers located in safe area.

13.4 Equipment that are tested / certified by a recognized test laboratory of country of origin shall only be offered. The vendor shall possess valid test certificate issued by a recognized independent test house such as CMRI/ BASEEFA/ UL/ FM or Equivalent for the offered equipment.

13.5 All equipment (indigenous or imported) shall have valid statutory approval as applicable for the specified hazardous location from CCE or any other applicable statutory authority. All indigenous flameproof equipment shall also have valid BIS license and corresponding marking as required by statutory authority.

13.6 A separate name plate shall also be provided on each equipment to indicate details of testing agency, test certificate number with date, statutory approval number with date,
approval agency, BIS license number with date, applicable gas group, temperature class etc. The nameplate shall be riveted/ fixed with screws and not pasted. In case above information are embossed on the enclosure, the same need not be repeated.

14.0 ENGINEERING REQUIREMENTS

Unless specified otherwise, vendor shall design entire fire alarm system including design of system architecture with details of integration, cabling requirement and protocol selection etc. Vendor's scope shall also include basic design and preparation of layouts for fire alarm system for plant/ buildings as specified in the data sheet/ purchase documents.

14.1 Conventional Fire Alarm System

i. For conventional fire alarm system, purchaser shall provide typical block diagram. On this basis, vendor shall prepare detailed drawing giving various system component details. The design and engineering shall include sizing and selection of various equipment such as fire alarm panels, batteries, battery chargers, field equipments, siren/ siren starter etc. including preparation of G.A. drawings of various equipment.

ii. The layout engineering for buildings shall include the drawings showing location of MCP/ Detector and other field devices, cable schedules, interconnection diagram, equipment installation drawings etc as minimum.

14.2 Addressable Fire Alarm System

i. Vendor shall develop a system architecture based on purchaser's requirement showing details of various network elements such as DGFAP, CFAP, Work station, networking hardware, redundancy, protocols, data highway etc. including the maximum permissible loop length and length of data highway.

ii. The design and engineering shall include sizing and selection of various equipment such as fire alarm panels, batteries, battery chargers, field equipments, siren/ siren starter etc. including preparation of G.A. drawings of various equipment.

iii. The layout engineering for buildings shall include the drawings showing location of MCP/ Detector and other field devices, cable schedules, interconnection diagram, equipment installation drawings etc. as minimum.

iv. The parameterization facilities of various field devices along with the geographic mimic, annunciation, text messages etc shall be available on the fire alarm panel.

15.0 INSPECTION, TESTING AND ACCEPTANCE

15.1 All the equipment shall be tested to the defined specifications as per mutually agreed test plan/ FAT procedure, which shall be submitted and got approved from Purchaser at least one month before inspection. PMC/ Purchaser's inspectors shall witness all the tests.

15.2 During manufacture, the equipment shall be subject to inspection as per attached inspection plan to assess the progress of work and to ascertain that the quality controls are being maintained. Vendor shall provide all necessary assistance and information concerning the supply to PDIL/Purchaser's inspectors.

15.3 Tests shall be carried out at the vendor's works under his care and expense and Purchaser shall be informed at least 4 weeks in advance regarding this.
15.4 FAT shall include simulation of operational field conditions and test for functional adequacy. Besides all routine, and acceptance tests specified by applicable codes and standards, shall be performed on the complete system.

15.5 For bought out items, the routine and acceptance tests shall be conducted at the respective equipment manufacturer's works.

15.6 At the time of inspection, vendor shall produce original of all the type test certificates, test and approval certificates for hazardous area equipment from testing and approving authority and any other certificates as required from statutory authority for the review of inspectors.

15.7 Vendor shall submit a SAT procedure for PMC/ Purchaser's approval. All equipment and systems shall be tested at site as per the approved SAT procedure.

15.8 SAT shall be conducted by vendor after the entire fire alarm system is installed and interconnected by cables. These tests shall establish the operational correctness of the system. Vendor shall rectify deficiencies noticed during SAT with no commercial implication to Purchaser including replacement of system components and supply of new component for making system successfully operational.

16.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight' etc., shall be clearly marked on the package together with Tag nos., Purchase order Nos. etc. The equipment may be stored outdoors for long periods before erection. The packing shall be completely suitable for outdoor storage in areas with heavy rains/ high ambient temperature.

17.0 INSTALLATION AND COMMISSIONING

Where installation of the system is included in the scope of the vendor, vendor shall arrange all necessary manpower and equipment required for the same. Commissioning of the complete system is to be carried out by vendor in all cases irrespective of whether the installation was performed by vendor or not. All tools, test equipment etc. for the successful commissioning of the system shall be arranged by the vendor. Only the cabling specifically excluded from vendor's scope shall be installed by others. However, termination at panels for purchaser's cables shall be done by the vendor.

18.0 TRAINING

The vendor shall provide, free of cost, comprehensive training to Purchaser's personnel on various operation and maintenance aspects of the Fire Alarm system as agreed during ordering.
TECHNICAL SPECIFICATION

PASSENGER CUM GOODS LIFT
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1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, supply, erection, testing and commissioning of general purpose Passenger cum Goods Lift.

1.2 The scope of work shall include, but not limited to the following items:

i) Haulage mechanism
ii) Counter weights
iii) Guides
iv) Car with frame
v) Landing gates
vi) Door frames
vii) Control Panel
viii) Brakes
ix) Indication
x) Car lighting arrangement
xi) Car telephone
xii) Car Ventilation
xiii) Earthing
xiv) Gas Mask
xv) All other items not specified, but required for safe and proper operation of the lift.

1.3 The LSTK contractor will provide power/ lighting/ DC supply through a single feeder required at a suitable point in the machine room. The supplier shall include the isolation switch and all distribution equipment, cabling and wiring required for power, control and car lighting, telephones for the safe and proper operation of the lift. General lighting of the machine room and the landings are excluded.

1.4 Civil and structural work required for lift well, lift pit and machine room shall be provided by the LSTK contractor in accordance with the requirement indicated by the supplier. However, necessary scaffolding in the hoistway, minor civil work, pit ladder, hoistway wiring, all steel material required for supports, lift shaft, bearing plates, buffer support channel, separator channel, sill support angle etc. are included in the scope of work.

1.5 The manufacturer shall be responsible for obtaining statutory approval for all equipment in lift installation from the factory inspector/electrical inspector of the state where the same is installed.

1.6 The vendor shall indicate the power requirement, loads and other details for structural design within 6 weeks from the date of L.O.I. to enable the LSTK contractor to provide the above mentioned services.

2.0 STANDARDS TO BE FOLLOWED

2.1 The equipment and installation shall conform to the latest issues of the following relevant Indian Standards. Equipment complying with equivalent IEC standards shall also be acceptable.
The design, installation and operational features of the equipment shall also comply with the provisions of the latest version of the following Acts and Statutory Regulations.

b) Lift Act
c) The Indian Electricity Rules
d) Fire Insurance Regulations

The supplier shall make suitable modification, addition/ alterations in the equipment, wherever necessary to comply with the above mentioned Act/ Rules/ Regulations.

Wherever any requirement laid down in this standard differs from that in Indian Standards, the requirements specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy - Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy - Electrical.

4.0 OPERATIONAL REQUIREMENTS

4.1 All electrical equipment shall be Flameproof/ Increased Safety/ hose proof type design for successful use in the extreme conditions of voltage and frequency variations without exceeding the maximum specified temperature.

4.2 For control and safety features, 115 Volts A.C. single phase, 50 Hz supply shall be used. This shall be arranged by the supplier by suitable double wound stepdown transformers with one pole earthed. Where D.C. supply is required, necessary rectifiers etc. shall be included in the offer. 110 V/ 220 V D.C. supply will be provided by the LSTK contractor for operating the emergency alarm bell and Emergency light in case of power failure.
4.3 **Method of Power Control**

4.3.1 The operation of the lift shall be automatic without the need for any car attendant.

4.3.2 **Operating Devices**

i) **In the Car**

Flush type attractively finished metal panel housing push-buttons one for each landing, an emergency stop push button, light switch, fan switch and an alarm switch shall be installed in the car.

ii) **In each landing**

a) Flush type attractively finished metal housing shall be installed at each landing with a single push button for calling the lift. The call button shall not be provided at emergency landings. However, door at all emergency landings shall be provided.

b) Dust protective (car door open) lights shall be provided at each landing in a separate metal housing installed on the wall.

c) All normal & emergency landing doors shall be manually operable having single leaf spring closing feature.

4.3.3 **Normal Operation**

The car cannot be started unless the car gate is in the closed position and all hoist-way doors are in the closed position. Momentary pressure on a car button shall move the car to the landing selected where the car shall stop automatically. Uninterrupted movement of the car shall be ensured until the desired landing is reached.

A time relay shall be provided to make the car inoperative for a few seconds after the desired landing is reached or whenever a stop command is given. This interval shall be adjustable but sufficient to permit a passenger to enter the car or leave the car including the close/open operations of the car gate and hoist-way door. The closing and opening of the car gate shall be done manually on entering the car.

4.3.4 **Emergency Operations**

In case of power failure, suitable provision shall be made for manual hoisting or lowering of the lift to the nearest landing. It shall be possible to open the car gate and landing doors manually at which the car is at rest in the event of failure of power.

5.0 **MACHINE ROOM**

The machine room shall be located at ground floor above 0.5 m from finished floor level. Machine room shall be freely ventilated through openings fitted with fixed louvers and exhaust fan. Access to this machine room shall be provided through an adequately sized aluminium door for an easier removal of the equipment installed therein. The supplier shall indicate the details of machine room viz size etc. Any other arrangement required for the safe operation of the equipment shall have to be provided by the lift vendor.

6.0 **GENERAL DESIGN & CONSTRUCTIONAL FEATURES**

The design of the lift and the associated equipment as well as their installations shall be in accordance with the latest engineering practice.
7.0 GENERAL DESIGN & CONSTRUCTIONAL FEATURES OF MECHANICAL EQUIPMENT

7.1 Loading and Stresses

7.1.1 All mechanical equipment shall be efficient in design for ease of erection, installation & maintenance.

7.1.2 The factor of safety for any part of the lift must not be less than 5 but higher factor shall be adopted for the parts specified in the relevant IS/IEC.

7.1.3 Loads and their combination thereof and maximum permissible stresses shall be as per relevant IS/IEC specifications.

7.2 Material of Construction

7.2.1 All materials of construction used for the lift shall conform to the relevant IS Standards and codes of practices or equivalent IEC.

7.2.2 All equipment enclosures shall preferably be of cast aluminium.

7.2.3 All external bolts and nuts including stay bolts up to 8 mm dia shall be of stainless steel and for sizes above shall be of M.S. cadmium plated.

7.2.4 Name plates on equipment shall be made of stainless steel with the letters embossed on them.

7.2.5 All pulleys shall be anti-spark type.

7.2.6 Exposed copper & copper alloys are not permitted to be used.

7.3 Lift Machine

The machine shall be of the single wrap traction type and shall include the driving motor, electromechanical brake, steel worm, bronze gear, steel sheave shaft and sheaves etc. mounted on a single base plate. The worm shaft shall be provided with ball bearings to take the end thrust. Roller bearings shall be provided for sheave shaft to ensure alignment and long bearing life. The driving sheave shall be helically grooved to ensure proper traction and minimize rope wear. Adequate arrangement for lubrication shall be provided for all bearings from single application point and oil filled worm gear.

7.4 Guides and Fixtures

Rigid guides of steel construction of sufficient strength, round section or ‘T’ section type with machined working surface shall be used for guiding lift car and counter-weight throughout their travel.

Guides of ‘T’ section shall be held rigidly to their fastenings by through bolts or by clips to restrict torsion. These shall be so jointed and fixed to their brackets that the guides shall not deflect by more than 3 mm laterally under normal operation. Guides and their fixing shall withstand application of safety gear when stopping a fully-loaded car or counterweight. Guide bracket shall be fixed to walls, plate inserts or stair stringer by bolts or bolted to the building or structural steel work.

7.5 Buffers

Buffers shall be installed under the lift car and top of the car and counterweight in
according to the requirement of IS or as per relevant IEC. These shall be complete with steel mounting members.

7.6 Lift Frame

The car shall be carried in steel car frame sufficiently rigid to withstand the operation of the safety gear without permanent deformation to the car frame. The deflection of the cross head members and the members carrying the platform shall not exceed 1/1000 of the span under static conditions with the contact load evenly distributed over the platform. At least 4 sets of roller guides shall be provided, two at the top and two at the bottom of the car frame. Necessary Facia Cover Plates for supporting the door frames on various landings shall be provided. Necessary safety devices shall be mounted underneath the car platform.

7.7 Lift Car

7.7.1 The car shall be of rigid construction for use in a chemical plant. The fittings inside the car should be properly protected against damage by tools or pipes, etc. carried by Workmen and by the corrosive action of chemical dusts and vapours.

7.7.2 Lift car shall be provided with roof, gates and car enclosure and the dimensions shall be as per IS: 4666 or as per relevant IEC.

7.7.3 Lift car shall have a 20 Watts fluorescent fixture suitable for hazardous area classification as per requirement.

7.8 Car Enclosure

The enclosure and door shall be of Stainless Steel 2.0 mm thick. Doors shall be able to withstand thrust of 35 Kg. applied normally at any point without any permanent deformation. Car enclosure shall be rigidly secured to the car floor & car frame.

7.9 Car Platform

Car platform shall be of steel construction suitable for specified contract load. The flooring shall be of 5 mm thick aluminium chequered plate bolted to the platform members. Car platform should have an apron of sufficient depth so as to prevent any object being trapped between car platform and lift landing.

7.10 Emergency Exit

A hinged cover not less than 600 mm x 450 mm opening upwards shall be provided in the car roof to serve as an emergency exit. The emergency exit shall be provided with an electrical interlock which will prevent the lift from being operated when the emergency exit is left open.

7.11 Load Plate

A plate showing the lift capacity shall be fitted inside the car. The load-plate shall indicate in a tabular form various combinations for number of passengers and goods loads permissible for safe operation in compliance with the applicable lift act.

7.12 Car Gate

The car gate shall be collapsible door and steel painted with anticorrosive paint. The gate shall be hung on an aluminium track by Nylon rollers and guided in a finished
groove sill on the car platform. The hangers and tracks for doors together with their fixtures shall be of adequate strength and rigidity. Means shall be provided to prevent the collapsible door from jumping the tracks or jamming. Suitable stops shall be provided to prevent the hanger carriage from leaving the end of the track. The distance between the collapsible car door & landing door shall be Min. 145 mm.

7.13 Hoist way Doors

The supplier shall furnish and install at each landing, steel swing doors with 2 mm thick & secured to give a clear opening of 900 mm width x 2000 mm height complete with door frames, hinges, handles, vision panels and door closures. The door shall be spring closing type.

7.14 Car Safety and Governor

Car safety device shall be provided to stop the car in case of excessive descending speed. The safety devices shall be operated by a centrifugal speed governor located at the top of the hoistway and connected to the governor through a continuous steel rope. The tension frame of the governor part at the bottom of the hoistway shall have stainless steel shaft. Suitable means shall be provided to cut-off power to the motor and apply the brake on application of the safety device. The rollers of the safety devices shall be of stainless steel.

7.15 Counterweight

The counter weight shall be provided for smooth operation. This shall be constructed of multiple sections of cast iron weighted with lead discs and two tie rods passing through holes in all sections. Two tie rods shall be provided for safety reasons. The counterweights shall withstand the effect of buffer impact. Renewable guide shoes shall be provided at the top and bottom of the weight. Screen protection for the counter weights shall also be provided.

7.16 Sheaves and Beams

Car and counter weight sheaves shall be provided as required. The sheaves shall be of cast iron grooved for the hoist ropes, sheaves shall have grease lubricated bearings.

7.17 Suspension Ropes

Hoisting ropes and compensating ropes of sufficient length made of galvanised traction steel shall be provided in the lift. They shall have PVC sleeving. Two ropes, independent of one another shall be used for suspension. Suspension ropes shall be in accordance with IS: 2365.

7.18 Cat Ladder

A cat ladder shall be provided throughout the length of the lift shaft for facilitating the escape of person trapped inside the lift car. The cat ladder shall be made of either stainless steel or suitable aluminium alloy. It shall be fixed to the lift well plate inserts or structure.

8.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES OF ELECTRICAL EQUIPMENT
8.1 **Main Switch**

One No. heavy duty switch fuse unit rated for 415 V, 63 A shall be provided by the lift supplier in the Control Panel/Sub-control Panel to receive the incoming supply.

8.2 **Lift Motor**

Motor for use in the lift shall be as per IS: 8151 and suitable for lift duty. It shall be of squirrel cage design, class F insulated (temp. rise limited to that of Class B), totally enclosed fan cooled type, having an enclosure of IP55 as per IS: 4691. The temperature rise of the motor throughout the working range shall not exceed the value specified in IS: 325. The terminal box and cable glands for motor shall be suitable for classified hazardous area.

8.3 **Brake**

A Solenoid Operated brake having at least two brake shoes shall be provided. The brake shall be spring applied and electrically released type. This shall be capable of bringing the lift car to smooth stops under variable loads.

Earth fault, short circuit or residual magnetism shall not prevent the brake from being applied when the power supply to the lift motor is interrupted. Means of releasing the brake in emergency case shall be provided.

8.4 **Controller**

A floor mounting cubicle type control panel shall be supplied to control the operation of the lift. The controller shall house the devices for starting, stopping, speed control of the lift motor and automatic application of the brake after the desired operation, operation of the safety devices on power failure. Necessary protective equipment for each electrical equipment and circuits shall be provided. The components as well as their layout shall conform to the relevant ISS/IEC. The controller panel shall be fabricated out of CRCA steel having thickness of 2 mm or more. The doors shall be internally hinged type. The design shall be totally enclosed, dust tight and vermin proof. For dustproof-features neoprene gaskets properly held in positions shall be provided at all jointing surfaces. The panel shall be of adequate size (not less than 1000 mm width x 600 mm depth x 2200 mm height) so that the operating temperature in the panel is within the permissible limits. The controller shall be housed in the machine room without having any ventilation facilities. The entire panel shall be painted with 2 coats of epoxy based paints after suitable chemical treatments.

The main and auxiliary contactors and relays shall be liberally spaced inside the controller. They shall be marked with the designation. The wiring shall be carried out with 2.5 sq.mm solid copper PVC insulated conductors, neatly laid and bunched with PVC bands. They shall be numbered as per IS: 375.

A reverse phase relay shall be provided on the controller to protect the lift against phase reversal and phase failure.

A lockable maintenance/service control switch shall be provided. In service position all safety interlocks shall be in circuit whereas in maintenance position safety interlocks shall be by passed so as to carry out maintenance.

For external connections all the power and control wires shall be terminated in the terminal block. For power cable, crimped type Cu lugs shall be supplied. For control
cable, pressure clamp type terminal blocks shall be provided. Ferrules shall be provided on all the wires.

8.5 **Car Operating Panel and Hall Stations**

Both shall have heavily zinc plated sheet steel bore with aluminium cover fitted by means of stainless steel screws. A continuous neoprene rubber gasket shall be provided to make the box dust proof. The push button units shall be of reputed make subject to Purchaser’s approval.

8.6 **Car & Hoist way Junction Boxes**

The junction boxes shall be of 6 mm thick cast aluminium having neoprene rubber gasket for dust proofing. The size of the junction boxes shall be adequate for the termination of cables as required. The cover fixing arrangement shall be external and the fixing screws shall be of stainless steel.

8.7 **Terminal and Final Limit Switches**

The terminal switches shall be provided to slow down and stop the car automatically at the terminal landings.

The final limit switches shall be provided to automatically cut off the power and apply the brake in case of the car travelling beyond the terminal landings.

All the limit switches shall be of positive action type. The operating arms and rollers shall be of stainless steel. The moving pins shall be made of stainless steel supported on oil-less bronze bushings. The enclosure of the limit switches shall be of cast aluminium provided with neoprene gasket.

8.8 **Car Gate Interlock**

An electrical interlock shall be provided in the car gate to prevent the movement of the car away from a landing unless the car gate is in the closed position. Effective locking devices shall also be provided to prevent the opening of the gate unless the car is on a particular landing.

8.9 **Hoist way Door Interlock**

Each hoist way door shall be provided with an approved interlock to be operated by a retiring cam on the car to prevent the movement of the car away from the landing unless all the doors are closed and locked. The interlocks shall also prevent opening of the doors except at the landing where the car is stopping or has stopped. The retiring arm shall be provided with dust protective covers.

8.10 **Door Open Bell**

An industrial bell shall be installed on the car to ring while a landing button is pressed and the car gate is open. The bell shall be for 110 V DC.

8.11 **Car Travelling Cable**

All electrical connections to the car shall be made by means of a multi-core hanging copper conductor flexible cable, one end of which is connected to terminal box fitted above the car, the other to a terminal box fitted in the well at approximately the mid-
position. These travelling cables shall conform to B.S.S. 977 having FRLS properties also. All car connections from the controller shall run to the well terminal box. The length of the flexible cable shall be approximately equal to half the lift total travel plus 5 meters so that the car may travel from end to end of the well without subjecting the cable to any strain.

8.12 **Wiring**

From the safety aspect, it is essential that all electric cabling and wiring be carried out in a sound and efficient manner and be in accordance with IS:732.

8.13 **Telephone**

An arrangement for installation of a telephone set inside the lift car shall be provided. This shall include an aluminium cabinet for telephone set having hinged door and flushed with the lift car with proper nameplate on the door.

Necessary leads shall be provided on the travelling cable for this purpose. The LSTK contractor shall terminate the exchange cables in the machine room. Necessary arrangements shall be provided to receive this. The receiver shall be supplied and installed by the supplier. Necessary terminal block shall be provided in the cabinet for this purpose.

8.14 **D.C. Lighting**

One No. 60 W, 110 V DC lighting fixture shall be provided in lift car for lighting in case of power failure.

8.15 **Earthing**

The metal framework of the motors, controllers/switchgear, electrical equipment in the car, car metal framework, guide rails & buffers and the electric conduit shall be effectively earthed in accordance with the latest issue of Indian Electricity Rules and IS:3043. The cross-sectional area of the earth conductor in the travelling cable shall be equal to that of the current carrying conductors. All equipment shall be earthed at least by two separate earth conductors.

9.0 **PAINTING**

9.1 All vendor equipment shall be painted with two coats of corrosion resistant epoxy based paint after suitable pretreatment.

9.2 The pre-treatment shall include treatments for removal of dust, scale and other foreign matters, epoxy based primer coating and final painting by spraying.

9.3 All fabricated items shall have shop coating of the primer only. Painting shall be carried out at site after their installation. The site painting shall have one coat of corrosion resistant epoxy based primer followed by two coat of epoxy based paint by spraying.

10.0 **TESTS AND INSPECTION**

10.1 All the items shall be routine tested as per relevant Indian Standards in the presence of Purchaser’s representative. The supplier shall give a fortnight notice to the LSTK contractor to enable its representative to be present for these tests.
10.2 In addition all the equipment shall be subject to stage inspection at works.

10.3 These inspections shall, however, not absolve the vendor free from his responsibility for making good any defects which may be noticed subsequently.

11.0 ERECTION, TESTING AND COMMISSIONING

11.1 The supplier shall undertake the erection of all equipment in accordance with established practices, in conformity with the statutory regulations and to the entire satisfaction of the LSTK contractor.

11.2 The supplier shall arrange all the necessary erection, tools and tackles including the supply of erection materials. The manufacturer shall also supply bulk lead lighting fitting inside hoist way to be provided at every 20 metres interval suitable for classified hazardous area.

11.3 The supplier shall to obtain the necessary clearance from the statutory authorities for equipment supplies and installation. All necessary drawings and test certificates as required by the authorities shall be furnished. Any modification/rectification, as required by the authorities shall be carried out.

11.4 Approved tests shall be performed on all equipment to the LSTK contractor’s entire satisfaction. All the test results shall be recorded and submitted to the LSTK contractor.

11.5 The entire installation shall be tested to prove the required performance in the presence of Purchaser's representative.

12.0 SPARES

12.1 Spares for operation and maintenance

Item wise unit prices of spare parts shall be quoted.

12.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

12.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

12.4 All spare parts shall be identical to the parts used in the equipments.

13.0 DRAWINGS AND DOCUMENTS

13.1 The drawings and documents as per Annexure-II shall be supplied unless otherwise specified.

13.2 All drawings and documents shall have the following descriptions written boldly:

i) Name of client
ii) Name of consultant
iii) Enquiry / order number with plant / project name
iv) Equipment Code No. and Description
13.3 At the time of handing over of the installation, the supplier shall supply as-built drawings taking into consideration the actual execution carried out.

14.0 DEVIATIONS

14.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
### ANNEXURE – I

**DOCUMENTATION FOR PASSENGER CUM GOODS LIFT**

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**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
TECHNICAL SPECIFICATION

SOFT STARTER
## CONTENTS

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1.0 GENERAL

1.1 Scope

This specification covers the general requirements for design, manufacture, assembly, inspection and testing at the Manufacturer's works of high voltage indoor soft starters above 1100V grade.

1.2 Data sheet

Contractor shall submit the data sheet in the Bid.

1.3 Codes and standards

The design, manufacture, testing and performance of soft starter panel shall comply with all current statutes, regulations and safety codes in the locality where the equipment will be installed.

Unless otherwise specified, the soft starter shall confirm to the relevant Indian, IEC or British Standards. Nothing in this specification shall be construed to relieve the Contractor of his responsibility. The relevant Standards are:

2. IS: 3156 (1992) Voltage Transformers. (Part - I to IV)
7. IS: 694 (1990) PVC insulated cables for working voltage upto and including 1100V.
8. IS: 6875 (1973) Control switches for voltages upto and including 1000VAC and 1200V DC. (Part - I to IV)
16. IEC 297 Dimensions of panels and racks.
17. IEC352 Solderless wrapped connections.
18. IEC 446 Semi-conductor converters.

2.0 GENERAL TECHNICAL REQUIREMENTS
2.1 **Design features**

(1) The thyristorised starter shall be used for starting of large induction motors.

(2) The soft starter shall give an excellent voltage control during soft starts, smooth steeples acceleration.

(3) The soft starter shall be used during starting for smooth and step-less acceleration only. Once motor gains its full speed bypass vacuum contactor shall be operated to bypass thyristors. The thyristor shall be short time rated (2 min.).

(4) The soft starter drive shall consist of the following.
   - Isolation vacuum contactor.
   - Bypass vacuum contactor.
   - Thyristor unit.
   - Motor protective devices.
   - Indicating / Metering / Control circuits and accessories.
   - Cooling / ventilation equipments / accessories.

(5) Soft starter shall have following minimum in built protection and alarm, but not limited to,
   - Electronic over load.
   - Line fault.
   - Under voltage.
   - Over voltage.
   - Stall.
   - Phase reversal.
   - Open gate for thyristor.
   - Over temperature for thyristor.
   - Over load for thyristor.

(6) Soft starter panel shall be provided with following indicating, metering and control devices.
   Motor starting / protection devices.
   Selector switch – Auto / Manual.
   Start / Stop push buttons for manual operation.
   - Input voltmeter and ammeter.
   - Meters to indicate power in MW.
   - Current and potential transformers.
   - Auxiliary relays.
   - Audio-visual alarms / fault indicators.
   - Alarm acknowledge / reset / test push buttons.
   - Provision for wiring external sequential / process interlock / signals for starting / running / tripping.
   - Terminals for remote control / indication.
   - Space heater and ventilating fans / cooler, if required.

2.2 **Performance requirement**

Soft starter panel shall be designed for operation at design temperature of 50°C. Contractor shall provide the necessary arrangement within the panel for satisfactory operation of soft starter.

2.3 **Construction**

(1) Soft starter panel shall be industrial type (Non-hazardous), totally enclosed, dust and vermin proof, floor mounted, free standing cubicle type of construction.

(2) The panel cubicle shall comprise rigidly welded structural frame enclosed completely by sheet steel of minimum 14 SWG (cold rolled) thickness, smooth finished, leveled and free from flaws. All doors and removable covers shall be provided with neoprene
gasket all around to make the cubical dust and vermin proof.

(3) The panel shall be provided with bottom sheet steel plates of minimum 2mm thick. Panel shall be fitted with removable gland plates of sufficient thickness at the bottom of the panel for fixing cable glands for power and control cable termination. Sufficient space shall be provided for termination of power cable sizes, as specified in data sheet.

(4) Louvers shall be provided at front, rear, top and bottom of the panel to dissipate heat developed inside.

(5) Degree of protection shall not be less than IP 4X.

(6) Panel shall be fitted with a label and serial number on the front and rear. In addition, panel shall be fitted with a label indicating panel designation and rating. All devices shall be provided with separate labels to indicate the function and also device numbers as marked in wiring diagrams.

(7) Main equipment of the panel shall be accessible for maintenance from the front and rear. All insulating material shall be flame resistant, non-hygroscopic and antitracking.

(8) All hardware's used inside the panel shall be zinc passivated or cadmium plated.

3.0 EQUIPMENT SPECIFICATIONS

3.1 HT Fuses

(1) High voltage fuses shall be of HRC link type and shall comply with the requirements of relevant standards.

(2) The fuse link shall have a striker pin for indication and also for trip mechanism.

(3) It is Contractor’s responsibility to precisely co-ordinate these fuses with contactors and upstream protective devices in the same system and shall be adequately rated for short circuit capacity.

(4) The type of fuse chosen by Contractor shall subject to approval by the Owner/Consultant. Contractor to furnish fuse pre-arcing time shall be furnished by along with the offer.

(5) Thyristor units shall be protected by fast acting semiconductor fuses

3.2 Vacuum contactors

(1) Vacuum contactors of adequate rating for the compressor motor starting at 11 kV Voltage to match the bypass & isolation application and shall conform to relevant India / IEC standards.

(2) Vacuum contactor shall be provided with properly designed and co-ordinated HRC fuses as mentioned in clause no. 3.1 above.

(3) DC operating coill shall be rated to operate satisfactorily between 80% and 110 % of the rated voltage. The contactor shall not drop out, if the voltage drops to 70% of rated voltage shall make arrangements to derive the auxiliary power, using necessary control transformer, for operating the contactor.

(4) The vacuum contactors shall have exclusively for Owners use minimum 1 NO & 1 NC auxiliary potential free contacts, rated for 10 amps, 240V AC and 0.5 Amp (inductive breaking) 110V DC or as specified and shall be wired upto the terminal blocks.

3.3 Instrument transformers

(1) The current transformers and Voltage transformers shall conform to the requirements stipulated in relevant standards. It shall Contractor’s responsibility to ensure adequate size of CT & VT

(2) The CTs & VTs shall be of cast resin type (insulation class “E” or better) and shall be able to withstand the thermal and mechanical stress resulting from the maximum short circuit and momentary current ratings of the switchgear.

(3) CTs shall have polarity mrks on each transformer and at the associated terminal block
Facility shall be provided for short-circuit and earthing the CT secondary at the terminal blocks.

(4) VTs shall be protected on the primary side by limiting fused and by MCBs on secondary side with 9kA interrupting ratings.

(5) The MCBs shall have min 1 NO + NC auxiliary potential free contacts, for annunciation and interlocks.

(6) CTs shall withstand specified system fault current for 1 sec.

3.4 Measuring and recording instruments

(1) Microprocessor based measuring and recording instruments shall be provided. The unit shall have RS-485 port at the output for serial communication.

(2) These instruments shall be standalone type, shall be configurable and shall be compatible with higher level computer.

(3) The instrument shall be rectangular in shape and not greater than 150mm (W) x 150mm (H). The accuracy class shall be as per IS or international standards.

3.5 Control wiring and terminals

(1) Feeders for Control (DC) / Auxiliary supply shall be provided at one point of the panel and voltage level shall be as specified in data sheet. Terminals to receive AC/DC control and auxiliary power shall be provided in cubicle and the terminals shall adequately rated (min. 20A).

(2) Adequate rated 2 pole MCBs shall be provided for each of the AC/DC control circuits.

(3) Internal wiring shall be done with 650V grade PVC insulated, stranded copper conductor of minimum size 2.5mm2 size.

(4) Separate colour coding shall be used for AC / DC control and power circuits and earth wire.

(5) All incoming and outgoing and control wire connection shall be wired to adequately rated (min.20A), elmex type terminal blocks about 20% spare terminals shall be provided in cubicle. All terminals shall be easily accessible.

(6) All wire shall be bunched together and routed through wire ways inside cubicle.

(7) Separate schematics, wiring diagrams and termination schedule for external and internal cable/wire connections shall be furnished by the Contractor. External connections shall include Owner’s remote equipment, which will be furnished by Owner to the Contractor.

(8) Low watt consumption LED type indicating lamps shall be provided.

(9) All wires, terminals and all other devices shall be provided with appropriate ferrules to correspond with wiring diagrams, for circuit identifications Termination lugs to be provided wherever necessary.

4.0 EARTHING

(1) An earth bus having cross section as specified in data sheet A shall be provided and extended through the length of the panel. All electrical equipment shall be connected to this earth bus.

(2) Suitable clamp type terminals with hardware at each end of the panel shall be provided to suit the size of the OWNER’s earthing conductor of size 75 x 10 mm GI

(3) Hinged doors shall be earthed through flexible copper brand of adequate size paint at earthing points shall be removed for proper contact star washers for door earthing are not acceptable.

(4) Bolted joints, splices, taps. etc to the earth bus shall be with at least two bolts

5.0 NAME PLATES AND RATING PLATES
5.1 Name plate

(1) Nameplate with engraved letters shall be provided for both front and rear side of panel function of every instrument, relay fuse etc shall be indicated by labels fixed near each device.

(2) Non-corrosive name plates shall be manufactured in anodized aluminium sheet and the letters shall be engraved on black lettering on white background. The name plates/labels shall be held in position by self-tapping screws.

(3) All devices mounted inside the cubicle and instruments etc., shall be identified by marking the device numbers inside cubicle as per the wiring drawing.

5.2 Rating plates

(1) The panel shall have a rating plate fixed to the non-removable part of the enclosure.

(2) All electrical equipment like VTs, CTs, etc and all other electrical devices shall be provided with rating plate made of stainless steel which can be easily seen.

(3) The rating plates shall give all the relevant information as specified in relevant standards.

(4) Danger boards, caution boards, operating instruction plates, shall be fixed to panel as per the standard engineering practice and regulations.

6.0 ACCESSORIES

6.1 Heater

Soft starter panel shall be equipped with space heaters to prevent moisture condensation within the enclosure and shall be suitable for continuous operation on 240V, 1 phase, 50 Hz AC supply. The space heaters shall be controlled through thermostats. Supply for motor space heater shall be brought to separate terminals in respective cubicle.

6.2 Cooling

Soft starter panel shall be provided with necessary ventilation / cooling equipment's for smooth operation of soft starter at given design temperature.

6.3 Plug Point

A 240V, 1 phase, 50Hz AC plug point shall be provided in the interior of each cubicle with an on-off switch.

7.0 PAINTING

(1) Oil grease, dirt and rust from the sheet steelwork shall be thoroughly Cleaned and removed. Rust and scale shall be removes by picking process with dilute acid and alkaline solution. Phospating and thorough rinsing with clear water followed by final rinsing with dilute dichromate solution and oven drying shall follow this.

(2) The under surface shall he prepared by applying a coat of phosphate paint and coat of yellow zinc chromate primer. The under surface shall be made free from all imperfections before under taking the finishing coat.

(3) After application of Primer, two coats of finish epoxy paint shall be applied with each coat followed be stowing. The colour shade for the finish paint shall be shade 631 (Light Gray) as per IS 5, unless otherwise specified.

8.0 INSPECTION AND TESTS
(1) Routine tests shall be carried out at works in the presence of OWNER/Consultant/Third party inspector as per relevant IS / IEC Standards.
(2) Contractor shall furnish type and routine test certificates for all bought out components for the panel, as per relevant standards.
(3) Test certificates for type test carried out on similar equipment of identical design, if available, shall be submitted along with the offer.

9.0 INFORMATION REQUIRED BY OWNER FROM THE CONTRACTOR

The Contractor shall submit following information in Bid: -
(1) Full technical description and performance details of the equipment accessories and components offered including heat losses for all components in kW.
(2) Overall dimensions and shipping dimensions and weight.
(3) Deviation taken by the Contractor from the requirements of this specification.
(4) Guaranteed technical particulars.
(5) Man-day rates for commissioning supervision.

10.0 MISCELLANEOUS

Each panel shall be provided with the following
(1) Two sets of clearly identifiable key for all panel-locking devices.
(2) Complete set of special tools and equipment for installation maintenance and testing of each panel.

11.0 PACKING

11.1 The switchboard shall be properly packed before dispatch to avoid damage during transport, storage and handling.
11.2 The packing box shall contain a copy of the installation, operation and maintenance manual.
11.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

12.0 DEVIATIONS

12.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
TECHNICAL SPECIFICATION
AUXILIARY SERVICE TRANSFORMER
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1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and despatch in well packed condition of auxiliary service transformers.

1.2 This standard shall be applicable for 3 phase / single phase, separate winding transformers of rating below 315 KVA used for Auxiliary services such as lighting, control, Instrument supply etc.

1.3 This standard shall be read in conjunction with the relevant specification sheet.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of following Indian Standards. Equipment complying with equivalent IEC standards shall also be acceptable.

- IS: 1180 Part - 1 & 2 -- Outdoor type 3 phase distribution transformers up to and including 100 KVA, 11 KV
- IS: 2026 -- Power transformers
- IS: 11171 -- Dry type power transformers

2.2 The design and operational features of the equipment offered shall comply with the provisions of the latest issue of the Indian Electricity Rules and other relevant statutory acts and regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy – Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy – Electrical.

4.0 OPERATING REQUIREMENTS

4.1 The transformer shall be suitable for operating at the rated capacity continuously at any of the taps, under the ambient conditions and with the voltage and frequency variations as indicated in specification sheet without exceeding the permissible temperature and without any detrimental effect on any part.

5.0 GENERAL DESIGN FEATURES

5.1 Rated voltage and frequency

These shall be as indicated in Design Philosophy – Electrical.
5.2 Phase connections

5.2.1 Three phase transformer
The primary winding shall be connected in delta and secondary winding in star with neutral point earthed (Vector group Dyn-11)

5.2.2 Single phase transformer
Primary winding shall be connected between two phases of a 3 phase system or to the three phases in open delta execution as specified in specification sheet and secondary single phase winding shall have one terminal earthed with the tank through link inside the secondary terminal box.

5.3 Tapping

5.3.1 The transformers shall be provided with off circuit tap changer with tapping of ± 2.5% and ± 5%.

5.3.2 For transformers having primary 3.3 KV and above, tap changing shall be effected with an externally operated handle, capable of being padlocked in any position on the primary side.

5.3.3 For transformers having primary 415V and below, tap changing shall be effected by means of links in the terminal chamber on the primary side.

5.4 Impedance voltage

The impedance voltage of the transformer at 75ºC shall be 4% unless indicated otherwise in specification sheet.

5.4.1 Losses

The losses shall be indicated by the vendor and shall be guaranteed, within tolerable limits specified in IS: 2026 at rated voltage and frequency.

5.4.2 Terminal Arrangement

The primary and secondary side terminals shall be brought outside the tank through porcelain bushing in dust and weather proof terminal boxes, with links for tap changing where required and suitable heavy duty double compression type aluminium cable glands and cable lugs for receiving cables as indicated in specification sheet. The neutral point of the secondary winding shall be brought out separately and earthed to the transformer body through test link. Terminal board for the primary and the secondary winding shall be amply sized and made of SRBP/ FRP materials.

5.4.3 Resistance to short circuit

The transformers shall be able to with stand electrodynamic stresses due to terminal short circuit of the secondary assuming primary side fed from the infinite bus.

5.4.4 Cooling System

Transformers rated up to 50 KVA shall be natural air cooled type and above 50 KVA shall be natural oil cooled / natural air cooled type as indicated in specification sheet.
6.0 CONSTRUCTIONAL FEATURES

6.1 Core

The transformer core shall be of high grade non ageing electrical silicon cold rolled magnetic sheet steel of low hysteresis loss and high permeability. The maximum flux density in any part of the core and yoke at rated voltage and frequency shall not exceed 1.7 Tesla for oil cooled transformers and 1.3 Tesla for air cooled transformers.

6.1.1 The tank for oil cooled transformer shall be made of mild steel plate of adequate thickness. Cooling tubes, where necessary, shall be provided.

6.1.2 Air cooled transformer shall be sheet steel enclosed having minimum thickness of 2.0 mm and shall be provided with suitable reinforcement as required. The minimum degree of protection for the enclosure shall be IP: 31. Ventilating louvers, if provided, shall be covered by fine wire mesh.

6.1.3 All external hardware shall be cadmium plated.

6.2 Windings

6.2.1 Coil shall be made out of electrolytic grade copper conductor.

6.2.2 Class-F / class-H insulating material shall be used for air cooled transformers.

6.2.3 For oil cooled transformer class-A insulating material shall be used. Mineral oil shall comply with IS: 325. 10% extra oil shall be supplied along with transformer in non-returnable drums.

6.2.4 Winding assembly shall be dried and impregnated in vacuum with tested insulating oil / varnish.

6.3 Bushing

The bushing insulators shall be rated for the maximum system voltage and shall comply with the requirement laid down in IS: 2099 / IS: 7421. The minimum current rating shall be 250A.

7.0 FITTINGS

7.1 Following fittings shall be provided for air cooled transformers.

i) Rating and diagram plate
ii) Lifting lug
iii) Primary and secondary cable boxes with heavy duty double compression type aluminium cable glands and lugs.
iv) Earthing terminals
v) Rollers (for 25 KVA and above)

7.2 In addition to the above following fittings shall be provided for oil cooled transformer.

i) Oil conservator complete with drain plug, oil filling hole with cover and oil level indicator with minimum marking.
ii) Silica gel breather
iii) Dial type thermometer
iv) Oil sampling cum drain valve
v) Explosion vent
vi) Air release plug

7.3 Any other fittings which may be necessary for satisfactory operation of the transformer shall also be provided.

7.4 All fittings shall conform to relevant Indian Standards.

8.0 PAINTING

8.1 The surface shall be painted after removing all dust, scale and foreign adhering matter. All traces of oil and greases should be removed by suitable treatment.

8.2 All steel surfaces in contact with insulating oil shall be painted with heat resistant oil insoluble insulating varnish.

8.3 All steel surfaces exposed to outside shall be painted with suitable anti rust and anti corrosive paints. Epoxy paints shall be used, if indicated in specification sheet.

8.4 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.5 Unless otherwise specified, the finishing shade shall be light grey shade no. 631 as per IS: 5.

8.6 1 litre paint per air / oil cooled transformer shall be supplied for touch up at site.

9.0 TESTS AND INSPECTION

9.1 All transformers shall be routine tested as per IS: 2026.

9.2 Additional tests, wherever specified, shall be carried out on one transformer of each rating.

9.3 All the above mentioned tests shall be carried out in the presence of purchaser’s representative. In addition, the transformer shall be subjected to stage inspection at works and inspection at site for final acceptance.

9.4 These inspections shall, however, not absolve the vendor from his responsibility for making good any defect which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 The drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of Consultant
- Enquiry / Order No. with plant / project name
- Equipment Code no. and Description

11.0 SPARES
11.1 Spares for operation and maintenance
   Item wise unit prices of spare parts shall be quoted.

11.2 Commissioning Spares
   Commissioning Spares, as required, shall be supplied with the main equipment. Item
   wise list of recommended commissioning spares shall be furnished for approval.

11.2 Any other spare parts not specified, but required, shall also be quoted along with the
   offer.

11.3 All spare parts shall be identical to the parts used in the equipment.

12.0 PACKING

12.1 The transformers shall be suitably packed in wooden crates to avoid damage in transit. Oil
   cooled transformers shall be properly sealed so as to completely exclude oxygen
   and moisture from coming in contact with oil.

12.2 The packing box shall contain a copy of the installation, operation and maintenance
   manual.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with
   reasoning.

13.2 Deviations, if any, from the data furnished in specification sheet shall be indicated
   therein beside the data by encircling it.
## ANNEXURE – I

### DOCUMENTATION FOR AUXILIARY SERVICE TRANSFORMERS

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<th>Sl.No.</th>
<th>Description</th>
<th>With Bid</th>
<th>For Approval</th>
<th>Final</th>
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<tbody>
<tr>
<td>1.</td>
<td>Specification Sheet, duly completed</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>2.</td>
<td>Technical Particulars, duly filled-in</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>3.</td>
<td>Dimensional drawing with terminal arrangement details</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>4.</td>
<td>Illustrative and descriptive literature</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>5.</td>
<td>Installation, Operation and maintenance manual</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>6.</td>
<td>Test Certificates</td>
<td>N</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>7.</td>
<td>Guarantee certificate</td>
<td>N</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>8.</td>
<td>Spare parts list with identification marks</td>
<td>N</td>
<td>N</td>
<td>Y</td>
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</table>

### Note:

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
TECHNICAL SPECIFICATION

DIESEL GENERATOR SET
## CONTENTS

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| ANNEXURE - I  | DOCUMENTATION FOR DIESEL GENERATOR SET           |
1.0 SCOPE

1.1 This standard covers the technical requirements of design, engineering, manufacture, assembly, testing at works and delivery in well packed condition of diesel generator set (D.G. Set) complete with all required accessories and control equipment to supply continuous electrical power.

1.2 This standard is applicable for D.G. set having rating more than 500 KVA.

1.3 The control panel for DG set shall be provided with Auto/manual starting/stopping facilities.

1.4. The scope of supply shall include, but not limited to the following:

a) Diesel engine, complete with all the required accessories and components.
b) Generator set, for operation with the above diesel engine, complete with all the required accessories and components.
c) Drive coupling between diesel engine and generator set complete with guard.
d) Engine flywheel, if required, with starter ring and guard.
e) Fuel oil system comprising of fuel oil tank, supply pump, filter, piping, valves, fittings etc.
f) Air intake system comprising of air blower, air filter, turbo charger etc.
g) Lubrication oil system comprising of lube oil pump, filter, cooler, piping, valves, fittings etc.
h) Jacket cooling system comprising of radiator, water circulation pump, necessary piping and fittings etc.
i) Starting system complete with battery, battery charger, starter motor, control system etc.
j) All inter connecting piping, valves and fittings up to the battery limits.
k) Torsional vibration damper at the free end of the crank shaft.
l) Speed regulation system.
m) Provision for hand barring of the engine along with the hand barring tool.
n) "Emergency-off" Push Button shall be provided on the enclosure if the DG set is provided with Acoustic enclosure. Emergency-off Push Button near DG set shall be provided even if acoustic enclosure is not provided.
o) Platforms, walkways, stairs and hand racks, as required, for adequate access during operation and maintenance.
p) A common base frame suitable for assembly of engine, radiator and alternator with there accessories. Anti, vibration mounting and foundation bolts shall also be supplied. Base frame shall be designed for transportation of above items duly assembled on it.
q) Exhaust manifold complete with silencers, asbestos lagging, metallic expansion bellows and piping.
r) All necessary instruments for monitoring and safe starting, running and stopping of the D.G. set their auxiliaries complete with tubing and cabling.

s) Control panel.

t) Cabling material between control panel and all equipment within the battery limit including cables, racks, earthing terminating materials etc.

u) All safety and protective devices.

v) Electrically operated Turning Gear Motor (DC powered).

w) All other items not specified here but, necessary for safe, satisfactory and uninterrupted operation of D.G. set.

x) Set of special tools and tackles required for installation and maintenance.

y) Spare parts for the specified duration.

z) All other services as required.

aa) These DGs shall feed to Main DG Power Supply Board. Emergency Power Distribution Switchboard shall have 2 Nos. incomers from Main DG Power Supply Board and shall feed emergency load of CPP, Coal Gasification Plant and other Offsite & Utilities of entire fertiliser complex.

1.5 Offered DG set shall also comply with CPCB/State Pollution Control Board norms/standards regarding emission & Noise. Necessary certificate regarding this shall be furnished by LSTK Contractor.

1.6 DG Set shall be designed to cater the non-linear loads i.e. VFD driven pump therefore effects of harmonics on DGs shall be considered while designing.

1.7 Erection and commissioning of the above shall be carried out by LSTK Contractor.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of the following codes and other relevant Indian standard specifications unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

i) BS 649 - Diesel engines for general purpose.

ii) IS:7451 - Reciprocating internal combustion engines

iii) IS: 4691 - Degree of protection provided by enclosures for rotating electrical machines.

iv) IS-10000 - Methods of test for internal combustion engine.

v) IS: 13364 - Specifications for A.C. Generator

vi) IS:12065 - Permissible limits of noise levels for rotating electrical machine

vii) IS: 12075 - Mechanical Vibration of rotating electrical machine with shaft heights 56 mm and higher-measurements, evaluation and limits of vibration severity

viii) ISO:8528 - Reciprocating IC Engine driven AC generating sets

ix) ASME codes.

x) IS/IEC:60034 - Rotating Electrical Machines - Specification.

xi) Oil coolers as per TEMA class “C”
xii) Any other standards/codes (BS, IS & equivalent International Standards) applicable.

2.2 Equipment designed and manufactured to other national standards shall be acceptable provided they are in no way inferior to the above mentioned standards. The Contractor shall supply English version of the relevant standard in such case.

2.3 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of the Indian Electricity Rules and other statutory regulations. The Contractor shall, wherever necessary, make suitable modification in the equipment to comply with the above.

2.4 Wherever any requirement, laid down in this standard, differs from that in Indian standard / IEC, the requirement specified here in shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy – Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy – Electrical.

4.0 OPERATING REQUIREMENTS

4.1 The D.G. set shall be suitable for “black start” operation. The equipment offered shall be suitable for operating at their rated capacity continuously under the ambient conditions and voltage & frequency variations indicated in Design Philosophy – Electrical, without exceeding the temperature rise limits specified in relevant standards and without any detrimental effect on any part.

4.2 The D.G. set shall be designed for continuous operation at full load or partial load and have the capability to run at 110% of the MCR for one hour in every 12 hrs.

4.3 The D.G. set covered under this standard shall be meant to supply power in one of the following modes.

Type A - Emergency power i.e. to provide reliable power due to failure or outage of normal supply automatically within a specified time to critical devices and equipment of the installation.

Type B - Stand by power i.e. to provide reliable power due to failure or outage of the normal supply to all devices and equipment of the installation.

Type C - Backup power i.e. to provide reliable power due to restriction imposed by the supply authorities of the normal supply to some section of the installation.

4.4 The D.G. set meant to supply emergency power (Type A) should start automatically and quickly on receipt of starting impulse from owner’s remote panel. Under such conditions, the auxiliary power and cooling water shall not be available. The starting and lubrication system shall be suitably designed to take care of these conditions and allow easy, safe and quick starting. The loading sequence and its duration are as specified by Owner elsewhere.
4.5 An electronic tri-vector meter with maximum demand indicator shall be provided in generator control panel to measure KWH, KVARH, KVAH and maximum demand in KVA.

4.6 The D.G. set meant to supply standby power (Type-B) shall be started automatically and conditions mentioned above shall also apply. However, the loading sequence is not automatic and hence need not be defined by Owner.

4.7 The D.G. set meant to supply backup power (Type-C) shall be manually controlled and started manually. Idle period may not be long and the requirement of auxiliary power and cooling water can be ensured due to the availability of the normal supply.

5.0 DIESEL ENGINE

5.1 General Design Feature

5.1.1 The diesel engine shall be of multistroke, multicylinder with mechanical fuel injection arrangement and complete with all the required accessories.

5.1.2 The engine output shall be at least 25% greater than the power required for the loads (including internal consumption by D.G. set) and loading sequence as required.

5.1.3 The engine shall be suitable for trouble free operation with high speed diesel conforming to IS: 1460.

5.1.4 The unbalance force transmission to the foundation shall be minimum. Critical speed of the assembly shall be sufficiently higher than the rated speed of the engine.

5.1.5 The engine shall be provided with turbo charger, filter and silencer mounted suitably on the engine frame and complete with necessary ducts work for air intake.

5.1.6 The engine shall be provided with exhaust silencer, necessary ducts, minimum 2 nos. expansion bellows and supporting arrangement from ceiling for exhausting the gases to outside.

5.1.7 The diesel engine shall be totally enclosed continuous duty, turbo charged system.

5.1.8 The engine shall consist of the following items:

- Radiator Cooling
- Radiator fan with guard
- Suitable flywheel
- Flywheel housing complete with starter gearing
- Flexible coupling, suitable to match flywheel, with safety guard
- Pneumatic starting systems with compressors (1R+1S) and air receiver and other accessories shall be provided.
- Electronically controlled Governor
- Fuel Pump/ Fuel Solenoid - PT fuel system
- Lube Oil Pump
- Fuel & Lube Oil Filters
- Lube Oil Cooler
- Air Cleaner, dry type
- Residential Silencer
- Flexible pipe for silencer, with necessary flanges.
- Suitable Turbocharger, driven from exhaust gas.
In built safety controls against following:
- Over speed shutdown
- High coolant temperature warning / shutdown
- Low coolant temperature warning / shutdown
- Low coolant level warning / shutdown
- Low and high battery voltage warning
- Weak battery warning
- Over crank shutdown
- Fail to crank shutdown
- Over current
- High voltage
- Low voltage
- Under / over frequency
- Phase sequence
- Reverse power (kVA & kVar)
- Low Lube Oil Pressure shutdown

One No. 2 pole, AC/DC type, on-off switch, mounted on suitable frame, shall be provided and connected between the Battery and Engine (Starter) in order to isolate the battery supply to the engine when required.

5.2 Fuel Oil System

5.2.1 The system shall comprise of gravity fed oil tank, unless otherwise specified.

5.2.2 The gravity tank shall be complete with the provision of filling up by Motor driven pump and Hand Pump from the standard drums. The motor driven pump and associated hose pipe shall be provided by the Contractor.

5.2.3 Relief/bypass valve to regulate pressure in the fuel supply line, return excess fuel to a return line and prevent the build-up of excessive pressure in the fuel system shall be provided.

5.2.4 The gravity fed oil tank shall be located at a height from floor and near the wall of the engine room. Suitable brackets / structure shall be provided by the Contractor for this purpose. The tank shall be fabricated out of M.S. plates in cylindrical construction. The capacity of the tank shall be adequate for 24 hours continuous running of the engine at full load. It shall be complete with valves for filling & draining, vent connection, level gauge glasses, level switches for low level alarm.

5.3 Jacket Cooling System

5.3.1 The engine shall be provided with radiator type air cooling system.

5.3.2 All the necessary items for the system such as water pump, radiator, fan, piping and fittings shall be provided to make the system complete in all respects.

5.3.3 Head tanks, if required, shall be included in the scope of supply for make up water as well as taking care of the expansion of the jacket water.

5.4 Lube Oil System

5.4.1 Proper lube oil system shall be provided for all lubricating points of the engine. The system shall be automatic pressure feed type and provided with a gear type pump driven from the crank shaft. The system shall be complete with fine wire mesh duplex strainer, valves, tank, oil cooler, header and branch piping suitably mounted on bed plate. Necessary accessories like pressure gauge, temperature and pressure switches for alarm and controls shall be provided.
5.4.2 The cooler shall be shell and tube type and connected to the engine cooling water system.

5.5 Starting System

5.5.1 The Electrical starting system shall be provided up to 1000 KVA DG set. However, for more than 1000 KVA DG set electrical / pneumatic starting shall be provided.

5.5.2 Both manual and automatic starting scheme shall be provided. The manual starting system shall be local while automatic starting system shall be suitable for impulses from owner’s remote panel.

5.5.3 The starting system shall be such that the D.G. set shall start & come up to rated speed and be ready to accept full load within the period as per the process requirement.

5.5.4 Starting time of the DG set should be minimum, but not exceeding 15 seconds, to start, accelerate and build up the desired voltage and frequency. If the first starting operation is not successful, 2 more attempts to start with preset time intervals should be made. If all the three attempts fail, the set shall be locked out, alarm shall be given.

5.5.5 The electric starting system shall comprise of starter motor, battery, battery charger, necessary cabling, required instruments and accessories.

5.5.6 The Ni-Cd battery shall be heavy duty type and suitable for 20 successive starting attempts of the engine without draining. The charger shall have both float / boost charging facilities. The battery shall be complete with suitable stand and other required accessories.

5.5.7 The pneumatic starting system may comprise of a camshaft driven rotary air distributor admitting air to a series of automatic air starting valves fitted on individual cylinder heads or an air cranking motor operating through a ring gear on the engine fly wheel. The pneumatic starting system shall consist of:
   a) One 100% capacity A.C. motor driven air compressor, additional engine driven air compressor shall be provided, as required.
   b) One air receiver of adequate capacity to supply air for minimum six (6) starts of engine.
   c) Solenoid operated valves.
   d) Pressure switches for automatic starting and stopping of the compressor.
   e) After-coolers for compressor, if required, suitable for raw cooling water.

5.5.8 The compressor for charging the starting air receiver shall be driven by an A.C. motor. The starting and stopping of this motor driven compressor shall be controlled automatically by suitable pressure switches so that the air receiver remains charged always.

5.5.9 Contractor shall provide all necessary devices including solenoid valves so that with an impulse for starting of the engine received from emergency equipment or manual start push button, the entire operation of starting of the diesel set shall take place automatically.

5.6 Governing System

5.6.1 The speed governing system of the diesel engine shall satisfy the following requirements:
   a) Steady state speed regulation shall be adjustable between 0 to 5% manually.
   b) Steady state speed regulation once fixed, shall not vary beyond + 0.5%.
c) Transient speed regulation shall not exceed 4.5% of rated speed. Momentary under speed and over speed shall not exceed 2% and 8% respectively.

d) Recovery time shall be within 3 seconds.

5.6.2 The governor system shall be electronic type and provided with adequate scheme to control the speed in the event of failure of power to the governor.

5.6.3 The governor should have automatic start fuel limit feature so that fuel is limited during start up to prevent excess start up smoke and start up over speed. The automatic fuel limit should be adjustable.

5.6.4 A mechanical over speed trip device shall be provided to operate at 110% of rated speed.

5.6.5 An engine mounted emergency push button shall be provided to trip the engine in case of emergency.

5.6.6 Separate Tachometer shall be provided to indicate the speed of the engine locally.

6.0 GENERATOR

6.1 General Design Features

6.1.1 The generator shall be directly coupled to the engine.

6.1.2 The ingress protection class of the enclosure shall be IP44 as per IS/IEC:60529.

6.1.3 The generator and its accessories shall be capable of withstanding electrical, mechanical and thermal stresses while meeting the performance requirements.

6.1.4 The generator shall be synchronous A.C. Generator; star connected and shall have C.M.R. of specified output at 0.8 lag p. f. at rated voltage and frequency.

6.2 Winding and Insulation

6.2.1 The stator and rotor coils shall be made out of electrolytic grade copper conductors. Successive coils shall be connected by accessible and well brazed joints.

6.2.2 The coils shall be class F insulated and treated with tropical and fungicidal treatments.

6.2.3 The windings shall be dried, properly impregnated with suitable varnish to withstand the site conditions and properly baked. At least two additional impregnations and baking shall be applied to the assembled coil making a total of three impregnations and baking. Finally the windings shall be painted with special anti-acid and anti-alkali paint to withstand the site condition.

6.2.4 The leading wire between the windings and the outside terminals shall be through bushings.

6.3 Performance Requirement

6.3.1 The generator and the diesel engine shall match properly to deliver the rated load under the specified ambient and system conditions.

6.3.2 DG set shall be capable of starting from cold condition, taking up full load without undue wear and stress on equipment under the specified ambient and system condition. Also DG set shall be stopped manually using Emergency Stop push button, irrespective of the position of Auto/ manual selector switch located in Generator Control Panel.

6.3.3 The specified rating of the D.G. set indicated are net electrical power output required for owner’s use and does not include the power required by the auxiliaries of the diesel set.
The actual output rating of the generator to be offered by Contractor shall take into account the power requirement of the auxiliaries, 15% extra margin.

6.3.4 The generator shall have an overload capacity of 10% for 1 hour in any consecutive period of 12 hours after having attained the thermal equilibrium corresponding to the rated load. The terminal voltage shall be equal to the rated value. At the time of switching 'ON' the emergency loads, restarting or reacceleration of squirrel cage motors shall be required, in addition to switching 'ON' of the lighting loads, which will be six times the rated load at power factor of 0.35 lagging. The generator and its accessories shall be capable of supplying this load at the above mentioned low power factor. Limitations, if any, shall be clearly indicated by the Contractor.

6.3.5 The transient reactance shall be as low as possible to limit the voltage drop to 10% due to above loading conditions.

6.3.6 **Largest Motor Starting Requirement**

The D.G. set shall be designed such that it can start squirrel cage induction motor of specified rating by D.O.L. starting method when already loaded up to 80% of its rated load. The voltage dip at the generator terminal shall not exceed 10% of its rated voltage during the entire starting period which will not exceed 5 seconds.

Limitations of the engine size offered by the bidder, if any, shall be indicated clearly by the bidder.

Supporting calculation shall be supplied by the successful bidder for approval of the owner.

6.3.7 The short circuit ratio, of the generator at rated KVA and rated voltage shall not be less than 0.5.

6.3.8 The generator shall withstand 20% over speed for 2 minutes without any damage to any part.

6.3.9 The generator shall be capable of withstanding the three phase short circuit at its terminals while operating at its voltage without sustaining any damage.

6.3.10 The temperature rise of stator windings, exciter and other parts shall not exceed the limits specified in relevant IS.

6.4 **Excitation System**

6.4.1 The generator shall be provided with static brushless excitation system comprising of shaft driven rotor exciter, thyristor and other associated items.

6.4.2 The armature and field windings shall be class F insulated similar to that of generator.

6.4.3 The capacity of the system shall be adequate to meet the performance and largest motor starting requirement of the generator.

6.4.4 The AVR shall maintain the generator steady state terminal voltage within ±1% of nominal voltage for load variation from no load to full load at 0.8 P.F. (Lag) and for speed variation of 4.5%. Manual voltage trim facility for voltage adjustment of ±5% shall be provided for the AVR.

6.5 **Voltage Regulator**

6.5.1 The generator shall have static type voltage regulators to be mounted on the control panel. The regulator system shall be suitable to meet the following requirements:

a) Allow the generator to meet the performance requirements.
b) Both auto and manual control.
c) Prevent automatic rise of field voltage in the event of excitation supply failure.
d) Transfer to manual mode in the event of control circuit failure in auto mode.
e) Operated by the output current and voltage of the generator.

6.6 **Space Heater**

6.6.1 Space heaters rated for 240V A.C. shall be provided to keep the winding dry during idle conditions.

6.6.2 The location of the space heaters shall be such as to allow easy access for inspection, maintenance and replacement.

6.7 **Embedded Temperature Detectors**

6.7.1 The generators shall be provided with 6 nos. of embedded resistance temperature detectors for measurement of winding temperature. Three of these shall be provided between the coils, one in each phase and the other three at the base of the slots, one in each phase, placed 120° apart.

6.7.2 The ETD’s shall be of platinum having 100 ohm resistance at 0°C and temperature coefficient as 3.85 x 10⁻³.

6.7.3 The ETD’s shall be 3 lead type having power frequency insulation level of 2 KV.

6.7.4 The temperature indicator with selector switches shall be provided in the control panel.

6.8 **Terminal Boxes**

6.8.1 All the terminal boxes shall have IP-54 degree of protection.

6.8.2 The power and control terminal boxes shall be separate. All the six leads of the generator stator shall be taken out, three to one side and three to the other side to separate power terminal boxes.

6.8.3 The power terminal box shall be spacious and have adequate clearance between the terminals and the cable gland for proper termination of required nos. of aluminium cables.

6.8.4 The power terminal boxes shall be provided with tinned copper sockets suitable for crimping.

6.8.5 The control terminal boxes shall be provided with pressure type terminal blocks.

6.8.6 All terminal boxes shall be complete with heavy duty double compression type aluminium cable glands suitable for the cable sizes required.

7.0 **CONTROL PANEL BOARD**

7.1 **Requirements**

7.1.1 The control panel board shall comprise of control & instrument section, power & protection section and distribution section for satisfactory and trouble free operation of the set. Each section shall be a complete panel.

7.1.2 The control and instrument panel shall house the following:

a) All the required controlling elements for the engine, generator and exciter control, for both manual and automatic operations.

b) Panel mounted instrument
c) The required protective devices for the engine.

d) The audiovisual annunciation system indicating abnormal operating conditions.

e) Control switches and indicating lamps.

f) Automatic voltage regulator.

g) All other items, as required.

7.1.3 The power and protection panel shall house the following:

a) Circuit breaker in draw out execution suitable for local/remote operation and provided with protective relays, C.T.s, Ammeters, Voltmeters, KWH meters, Frequency meters, ON/OFF/Trip indicating lamps, control switches etc. for the control of generator.

b) M.W.S. operated A.C.B. in draw-out execution suitable for local remote operation and provided with protective relays, C.T.s, Ammeters, ON/OFF/Trip indicating lamps, control switches etc. for the control of outgoing power feeders, as indicated elsewhere.

7.1.4 The distribution panel shall house the following:

a) Necessary feeder circuit outlets complete with switches, fuses, contactors, overload devices, ON/OFF/Trip indicating lamps, Ammeters etc. for the D.G. set auxiliaries, if required.

b) D.C. battery charging equipment required for the start up and control of the D.G. set. The charger shall be complete with float and boost charging arrangement both in auto and manual mode.

7.2 General Design Features

7.2.1 The panels shall be free standing, floor mounting, identical, metal clad cubicle type in construction and placed side by side to form a compact assembly in dust/damp and vermin proof type equivalent to IP-54 as per IS-13947 Part-1.

7.2.2 The thickness of sheet steel members shall not be less than 2 mm for cold rolled steel. Suitable reinforcement, wherever necessary, shall be provided. The base channel shall be more than 3 mm thick.

7.2.3 The door hinge shall be concealed type. All threaded screws in the removable parts shall be provided with retaining rings.

7.2.4 All the components shall be accessible for checking and taking off without the necessity of removing the adjacent ones. Their mounting shall be accessible and ensure the necessary degree of safety.

7.2.5 The relays, meters, switches and lamps shall be flush mounted type. Their minimum mounting height shall be 900 mm from the base of the panel.

7.2.6 The bus bars shall be for three phase and neutral and made of electrolytic copper or aluminium of required cross section and PVC sleeved. These shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding the total temperature of 90°C. The thermal rating of the bus bars shall be designed to withstand the system fault current for one second without exceeding the temperature of 250°C for bare copper.

7.2.7 The clearances and creepage distance shall not be lower the values specified below:

7.3 Control Wiring

7.3.1 The panel board shall be completely factory wired and ready for external connections.
i) Minimum clearance between two live conductors - 20 mm.
ii) Minimum clearance between live parts and accidentally dangerous part - 20 mm.
iii) Minimum creepage distance - 28 mm.

7.3.2 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables for 1100 volts grade.

The size of wires shall be as follows:

C.T. Circuit - 2.5 sq. mm copper
V.T. & Control circuits - 1.5 sq. mm copper

7.3.3 All wiring shall be marked in accordance with IS-375. Numbered Ferrules reading from the terminals outwards shall be provided at both ends of all wiring for easy identification. These shall be interlocking type plastic ferrules.

7.4 Circuit Breakers

7.4.1 The circuit breakers shall generally comply with the requirements of IS: 13947, having P2 category, capable of carrying the specified current at the site conditions and making/breaking of the system fault current.

7.4.2 Type test certificates from an independent testing authority shall be furnished along with the offer, for each circuit breaker rating, which shall clearly prove the capability of circuit breakers and include the short circuit tests, temperature rise test, electrical overload tests and endurance test (both electrical and mechanical).

7.4.3 The circuit breakers shall be provided with motor wound spring closing mechanism and electrically and mechanically trip free and have anti pumping features.

7.4.4 The circuit breakers shall have three positions for service, test and isolated with the cubicle door closed, and position indicators provided to indicate the positions of the breaker. Stoppers shall be provided to prevent excessive movement of the breaker cradle than desired, for each position. Each position of the breaker shall have monitoring switch having 1 NO + 1 NC contacts.

7.4.5 Provision shall be made for testing the circuit breaker in test position.

7.4.6 Automatic safety shutters shall be provided to screen the cable and the bus bars spouts when the circuit breaker is withdrawn from the cubicle.

7.4.7 The circuit breakers shall be provided with an emergency manual trip device, mechanical ‘ON’ ‘OFF’ and ‘ISOLATED’ position indicators and operation counter.

7.4.8 Mechanical safety interlock shall be provided for safe operation movement of the breaker.

7.4.9 The closing coil and other associated auxiliary relays shall operate satisfactorily at all voltages between 85 to 110% of the rated control voltage. The tripping coil and other associated relays shall operate satisfactorily at all voltages between 70 to 110% of the rated control voltage.

7.5 Control Fuses

The fuses shall be of non-deteriorating HRC cartridge link type and conform to IS: 2208. They shall be suitable for the load and the service required in the circuit.
7.6 Current Transformers

7.6.1 C.T’s shall be cast resin emulated, accuracy class as per IS-2705, 1 for metering and SP/PS for protection.

7.6.2 All the C.T’s shall be provided with terminals and shorting links. One of the terminals of the C.T.s shall be earthed. The polarity of the C.Ts shall be clearly marked.

7.7 Voltage Transformer

The V.T. shall be cast resin insulated having secondary terminal voltage of 110V unless specified otherwise and accuracy class of shall be 1 as per IS: 3155 and provided with primary / secondary fuses.

7.8 Relays

All protective relays shall be provided in drawout and dust proof cases and shall be flush mounted type. They shall be fully tropicalised. Relays shall be of make and type as approved.

The following protective relays shall be provided.

i)  IDMTL over current and Residual earth fault.
ii) IDMTL standby earth fault.
iii) Over voltage or under voltage
iv) Reverse power
v) Hand reset tripping relay

7.9 Battery Charger

The charger shall be float cum boost, 415V, 3ph with fully controlled full wave rectifier type. The battery charger is required to provide 24V DC control supply and to charge the boost / float 24V Ni-Cd / SMF batteries. DG set battery (Ni-Cd/ SMF) shall be dedicatedly used for DG related power & auxiliary supply. Ampere hours shall be worked out with at least 30% spare capacity and 1 hours backup time.

7.9.1 The AMF control panel shall be complete with necessary control circuit fuses, nameplates, internal wiring, control terminals and cable glands & lugs.

7.9.2 The AMF control panel shall have provision for receiving starting impulse for the DG set from DG Power Distribution Board as well as to send out tripping impulses from AMF panel to the DG incomer breaker on DG Power Distribution Board.

7.9.3 All cable entries to the AMF panel shall preferably be from the bottom.

7.9.4 Automatic shutdown feature shall be provided for faults such as low lube oil pressure/ over speed/ high water temperature.

7.10 Instruments and Metering

7.10.1 All instruments shall be flush mounting type with square face of 96 sq. mm. They shall be tropicalised and dust tight. Make and type of instruments shall be as approved.

7.10.2 Marking of the scale shall be black on white background and suitable for direct reading.

7.10.3 Zero adjusters shall be provided for operation from the front of the cases.
7.10.4 All indicating instruments shall be moving iron spring controlled type of class 1.5 accuracy as per IS: 1248.

7.10.5 The KWH meter shall be as per relevant IS and provided with test blocks for current and voltage coils for testing them at site without interrupting their recording while in service.

7.10.6 The following instruments shall be provided.
   i) Voltmeter with selector switch
   ii) Ammeter with selector switch
   iii) Frequency meter
   iv) KW meter
   v) KWH meter

7.11 Signal Lamps

LED type signal lamps shall be provided to indicate the various circuit conditions and these shall be placed at suitable height. The colour of the lamps for various functions shall be as follows:

Red - Circuit breaker ‘ON’
Green - Circuit breaker ‘OFF’
White - Trip circuit healthy
Amber - Alarm and auto trip fault
Blue - Non trip fault

7.12 Name Plate

7.12.1 The panel board shall have a large name plate on the top to indicate its name and designation. Each feeder shall be provided with name plates. Each panel shall have name plates both in front and back.

7.12.2 All control switches, push buttons, lamps etc. shall have function identification labels.

7.13 Cable Termination

Necessary cable glands and lugs for power and control cables shall be provided.

8.0 INSTRUMENTATION

8.1 The instrumentation requirement shall include field / panel mounted instruments, push buttons, lamps, audio-visual alarm system and other accessories as required.

8.2 The provision required in the control panel board shall include the followings:
   i. Multipoint electronic self balancing temperature indicator with selector switch for generator winding.
   ii. Tachometer for engine speed.
   iii. Fuel oil day tank level indicator.
   iv. Audio-visual alarm system for:
      a) Low lube oil pressure
      b) Over speed of engine
      c) High jacket water temperature
      d) Low jacket water pressure
e) Winding temperature high  
f) All shutdown condition  
g) Other abnormal conditions, as required  

v. Shutdown system for:  
a) Maximum jacket water temperature  
b) Engine over speed  
c) Minimum lube oil pressure  
d) High winding temperature  
e) Generator faults  
f) Faults in the excitation system  
g) Failure of engine to start after a preset time  
h) Other faults, as required  

vi. Excitation control system complete with:  
a) Rheostat for manual control  
b) Automatic voltage regulator  
c) Field discharge resistance  
d) Diodes / Rectifiers  
e) All other items, as required  

vii. Engine control system complete with:  
a) Auto / manual switch  
b) Control equipment and circuitry for Auto Mains Failure starting other than for type ‘C’ sets.  
c) Push buttons and other control equipment for manual start.  
d) Equipment and circuitry for pre-start priming, if required.  
e) Equipment and circuitry for repeated attempt to start.  
f) Indicating lamps for fail to start.  
g) Audio visual alarm as specified and required.  
h) Instrumentation as specified and required  
i) Operation hour counter  
j) All other items, as required  

8.3 The field mounted instruments shall include the followings:  
a) Pressure gauge for lube oil  
b) Dial type thermometer for jacket water and various bearings.  
c) Tachometer for engine speed.  
d) Fuel oil day tank level indicator.  
e) Other items, as required.  

8.4 The supply shall be complete with all instrument erection materials with 10% extra provision.  

8.5 All instruments, shall be suitable for site maximum ambient temperature, All electrical and electronic instruments shall be tropicalised and fungus proof.
9.0 ACCESSORIES

The D.G. set shall be complete with all required accessories, whether indicated or not, to make the installation complete in all respects and to ensure its safe and proper operation.

10.0 PAINTING

The enclosures, after suitable pre-treatment, shall be painted with two coats of anti rust paint followed by two coats of anti-corrosive epoxy based paints.

11.0 TOOL KIT

Special tool kit for the DG Set required for operation & maintenance of DG set shall also be supplied along with DG set.

12.0 TESTS AND INSPECTION

12.1 All routine tests as per relevant standards shall be carried out in the presence of Owner's representative.

12.2 The D.G. set shall be tested for output, general performance, overloads and other tests sufficient to prove the correctness of the design both at works and at site.

12.3 The tests to be carried out on various items are given below.

a) Diesel Engine

- Routine test as per relevant Indian / British / National standards.
- Test for speed regulation with a sudden loading of 50% of rated capacity with zero base load.
- Starting time of the engine from zero to full speed from the instant of start command.
- Operation check for satisfactory operation of the DG set.
- Over speed test at 120% rated speed and over speed trip.
- Load test and measurement of fuel oil consumption.

- 100% load for 4 hrs.
- 110% load for 1 hr.
- 75% load for 1/2 hr.
- 50% load for 1/2 hr.

All parameters such as jacket water temp., lube oil pressure and temperature will be checked.

b) GENERATOR

- Routine test as per IS 4722.
- Voltage regulation from no load to full load.
- Voltage trimming facility check.

c) Control Panel

- Routine tests as per IS 3623.
- Operation tests for AMF operation, operation of various devices and meters etc.
12.4 In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.

12.5 These inspections shall, however, not absolve the Contractor free from his responsibility for making good any defect which may be noticed subsequently.

13.0 SPARES

13.1 Spares for operation and maintenance
Item wise unit prices of spare parts shall be quoted.

13.2 Commissioning Spares
Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.

13.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

13.4 All spare parts shall be identical to the parts used in the equipments.

14.0 PACKING

14.1 The equipment shall be properly packed before despatch to avoid damage during transport, storage and handling.

14.2 The equipment shall be wrapped in polythene to make it water proof. Bags of silica gel shall be kept inside to absorb moisture present during transport and storage. An additional wrapping with bitumen paper shall also be provided before the equipment is packed in wooden crates.

14.3 A sign indicating the position of the equipment placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

15.0 DRAWING AND DOCUMENTS

15.1 Drawings and documents as per Annexure-I shall be supplied unless otherwise specified.

15.2 All drawings and documents shall have the following descriptions written boldly.
- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

16.0 DEVIATIONS

16.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
## ANNEXURE – I

### DOCUMENTATION FOR DIESEL GENERATOR SET

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Description</th>
<th>Documents Required (Y / N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>With Bid</td>
</tr>
<tr>
<td>1</td>
<td>Specification Sheet, duly completed</td>
<td>N</td>
</tr>
<tr>
<td>2</td>
<td>Technical Particulars, duly filled-in</td>
<td>N</td>
</tr>
<tr>
<td>3</td>
<td>General arrangement and foundation drg. for all the equipment.</td>
<td>N</td>
</tr>
<tr>
<td>4</td>
<td>Civil scope drawings</td>
<td>N</td>
</tr>
<tr>
<td>5</td>
<td>Earthing layout</td>
<td>N</td>
</tr>
<tr>
<td>6</td>
<td>Terminal arrangement drg. and Interconnection.</td>
<td>N</td>
</tr>
<tr>
<td>7</td>
<td>Sectional view of D.G. Set</td>
<td>N</td>
</tr>
<tr>
<td>8</td>
<td>Illustrative and descriptive literature.</td>
<td>N</td>
</tr>
<tr>
<td>9</td>
<td>Catalogue for bought out accessories.</td>
<td>N</td>
</tr>
<tr>
<td>10</td>
<td>Installation operation &amp; maintenance manual</td>
<td>N</td>
</tr>
<tr>
<td>11</td>
<td>Type test certificates for engine, alternator and circuit breaker</td>
<td>N</td>
</tr>
<tr>
<td>12</td>
<td>Guarantee certificate</td>
<td>N</td>
</tr>
<tr>
<td>13</td>
<td>Spare parts list with identification</td>
<td>N</td>
</tr>
<tr>
<td>14</td>
<td>Calculations for justifying DG set size offered with respect to load and starting of largest load.</td>
<td>N</td>
</tr>
</tbody>
</table>

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No
NOTE:

1. LAW ANNUNCIATION SHALL BE PROVIDED ON TRANSFORMER FEEDER.
2. COMMUNICATION PROTOCOL SHALL BE AS FOLLOWS:
   a. NUMERICAL RELAY – IS06550
   b. MULTIFUNCTION METER – INF10MODBUS
3. AUTO CHANGE OVER LOCK BETWEEN INCOMING AND BUS COUPLER SHALL BE DEVELOPED IN NUMERICAL RELAY
4. COMMANDS/INDICATION TO/FROM BOX SHOWN IN SLD ARE INDICATIVE.
5. THE SWITCH SHALL BE ABLE TO CLOSE ONLY IN TEST POSITION FOR ALL MOTOR FEEDERS
6. FOLLOWING MINIMUM METERING SHALL BE PROVIDED ON MULTIFUNCTION METER:
   - 3 PHASE CURRENT
   - LINE VOLTAGE
   - POWER FACTOR & FREQUENCY
   - ANALOGUE, ANALOGUE & DIGITAL
   - HOUR RUN (ONLY FOR MOTOR FEEDERS)
7. COMMON ALARM CIRCUIT FOR HONOR & BUZZER SHALL BE PROVIDED IN BUS COUPLER.
8. LAMP TEST PUSH BUTTON SHALL BE PROVIDED.
9. ALL RELAYS SHALL BE NUMERICAL TYPE UNLESS SPECIFICALLY MENTIONED IN SLD.
   AND EXCEPT THE FOLLOWING:
   - FTU FUSE FAILURE RELAY (80)
   - AC/DC SUPPLY SUPERVISION RELAY (80)
   - TRANSFORMER LOCKOUT RELAY (80)
   - TRIP CIRCUIT SUPERVISION RELAY (80)
   - BUS BAR DIFFERENTIAL SUPERVISION RELAY (9581 & 9582)
   - MOTOR FEEDER
   - 1S FOR ELECTRICAL TRIP (HARD RESET)
   - 3S FOR PROGRESSIVE TRIP (SOFT RESET)
   - ALL FEEDERs
   - 8S ELECTRICAL TRIP (HARD RESET)
10. SIGNALS/INDICATIONS TO/FROM BOX SHOWN IN SLD ARE INDICATIVE AND SHALL BE CONFIRMED DURING DETAL ENG.
11. CIRCUIT BREAKER 'ON', 'OFF' INDICATION SHALL BE PROVIDED AT THE BACK OF EACH PANEL. ALTERNATIVELY ALARM SHALL BE PROVIDED IN CASE PANEL BACK DOOR IS OPENED WITH BREAKER 'ON'.

PROJECT:

STEAM GENERATION PLANT FOR COAL BASED FERTILIZER PROJECT

TYPICAL 11KV SW. BD. SINGLE LINE DIAGRAM

PROJECTS & DEVELOPMENT INDIA LTD. – NOIDA
NOTE:

1. ENSURE TERMINAL PLATES FOR TRANSFORMER FEEDER PLAN FOR OTHER FEEDERS.
2. COMMUNICATION POINTS TO BE ADDED.
3. INSTRUMENTATION TO BE DATA.
4. AUTO CHARGE DURING SHORT BETWEEN POWER AND BUS COUPLER.
5. TWO SHUNT CAPACITORS TO BE PROVIDED IN BUS COUPLER.
6. BUS COUPLER SHUNT CAPACITORS TO BE PROVIDED ON INSTRUMENTATION PANEL.
7. AUTO CHARGE DURING SHORT BETWEEN POWER AND BUS COUPLER.
8. TWO SHUNT CAPACITORS TO BE PROVIDED IN BUS COUPLER.
9. BUS COUPLER SHUNT CAPACITORS TO BE PROVIDED ON INSTRUMENTATION PANEL.
10. STATION OR GENERATING TOWARDS BUS COUPLES FOR 35KV ARE RECOMMENDED AND SHALL BE CONNECTED USING BUS COUPLER.
11. CIRCUIT BREAKERS TO BE PROVIDED AT THE BACK OF EACH PANEL. ALTERNATIVELY, SHUNT CAPACITORS TO BE PROVIDED IN PLACE PANEL BACK DOOR IS OPENED WITH SHUNT CAPACITORS.
NOTE:

1. EIN ARRANGEMENT SHALL BE PROVIDED ON TRANSFORMER FEEDER FOR OTHER FEEDERS
2. COMMUNICATION PROTOCOL SHALL BE AS FOLLOWS
   - 4-20MA (RS-422) INTERFACE
3. LOAD CHARGE OVER LOCK BETWEEN GENERATOR AND BUS COUNTER SHALL BE DEVELOPED IN MANUFACTURED REPLACEMENT
4. DRAWINGS/PRINTING TYPING ETC. SHOWN IN RED ARE APPROVAL
5. THE FATIGUE WILL BE USED ONLY IN TEST POSITION FOR ALL MOTORS FEEDERS
6. FOLLOWING MECHANISM WEARING SHOE PROTECTED WITH INSULATION
   - 4-20MA INTERFACE
   - LINE VOLTAGE
   - VOLTAGE, CURRENT & FREQUENCY
   - TEMPERATURE & FLAME
   - WIND-UP PROTECTION
7. COMMUNICATION CIRCUIT FOR MOTOR & BUS COUNTER SHALL BE PROVIDED IN BUS COUNTER
8. LOAD FEEDER PROTECTED FEEDER SHALL BE PROVIDED
9. ALL FEEDER SHALL BE NUMBERED THE UNLESS SPECIFIED IN SHEET AND EFFECTUAL DESIGN
   - 4-20MA INTERFACE RELAY
   - LOAD CIRCUIT SUPPLY RELAY (10A)
   - WORKING CONTINUOUS CURRENT RELAY (10A)
   - LOAD SHUNT DIFFERENTIAL SUPERVISION RELAY (10A)
   - WORKING FEEDER PROTECTION (10A)
   - BUS FEEDER PROTECTION (10A)
   - 4-20MA INTERFACE RELAY
   - 4-20MA INTERFACE PROTECTION
10. DETAILS/POSITIONS WERE D.S. SHOWN ON SHEET ARE INDICATIVE AND SHALL BE CONFIRMED DURING ISSUE END
11. CIRCUIT BREAKER, MOVING PARTS, ETC. INDICATION SHALL BE PROVIDED AT THE SHOE OF EACH PANEL
    ALTERNATIVELY SHOW SHALL BE PROVIDED IN SHEETzeigt WURFEN & EFFECTUAL DESIGN.

THIS IS CONCEPTUAL ILO, DETAILS ILO SHALL BE PREPARED BY BIDDER & SUBMITTTER WITH BID

<table>
<thead>
<tr>
<th>GPT</th>
<th>BIDDER</th>
<th>DESCRIPTION</th>
<th>55</th>
<th>50/PF</th>
<th>575</th>
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<td>ITEM</td>
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<td>CLIENT—</td>
<td>TALCHER FERTILIZER LIMITED</td>
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<td>PROJECT—</td>
<td>STEAM GENERATION PLANT FOR COAL BASED FERTILIZER PROJECT</td>
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TYPICAL 0.415V SW. RD. SINGLE LINE DIAGRAM
FOUNDATION DETAIL OF
11/.433 KV TRANSFORMER

CABLE TRENCH

PLAN

TYPICAL DETAIL OF 11/.433KV T/F

SECTION X-X

NOTE:
TRANSFORMERS RATED ABOVE 10MVA SHALL BE MOUNTED ON 200MM x 8MM THICK PLATES.
NOTES:

TRANSFORMERS RATED ABOVE 10MVA SHALL BE MOUNTED ON 200MM × 8MM THICK PLATES.
NOTE :-

1. THIS STANDARD IS INDICATIVE ONLY, THE EXACT DIMENSIONS SHALL BE DECIDED AS PER TRANSFORMER
   SIZE & SUB-STATION LAYOUT.

2. TRANSFORMER GATE HEIGHT SHALL BE 250MM MORE THAN THE TRANSFORMER HEIGHT AND SHALL BE
   OPENABLE OUTSIDE.
NOTES:--

1. DIMENSION 'L' AND 'B' SHALL BE DECIDED BASED ON OIL VOLUME OF HIGHEST RATED TRANSFORMER.

2. ALL DIMENSIONS ARE IN mm

<table>
<thead>
<tr>
<th>SL No.</th>
<th>OIL CAPACITY</th>
<th>L</th>
<th>B</th>
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<tbody>
<tr>
<td>6</td>
<td>2000</td>
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<td>5</td>
<td>3000</td>
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<td>3.0</td>
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<td>3.5</td>
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<tr>
<td>1</td>
<td>10000</td>
<td>4.0</td>
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</table>
SECTION—A A

PLAN

X— DEPTH OF PANEL
Y— LENGTH OF TWO PANELS

NOTES:

1. THIS ARRANGEMENT SHALL BE APPLICABLE FOR M.C.C., DISTRIBUTION BOARDS, CONTROL PANELS ETC.

2. PANELS AFTER ERECTION SHALL BE TAG WELDED TO FOUNDATION CHANNELS.
SECTION—A A

X1 = DEPTH OF PANEL
X2 = FLOOR OPENING
X3 = FLOOR OPENING
Y = LENGTH OF PANEL

PLAN

NOTES:—

1. PANELS AFTER ERECTION SHALL BE BOLTED TO FOUNDATION CHANNELS

2. POWER & CONTROL CABLES SHALL ENTER THROUGH OPENING X2

3. DEPENDING UPON THE FINAL DATA FROM THE VENDOR, ONLY TWO CHANNELS MAY BE NECESSARY IN WHICH CASE THE 3RD. RECESS SHALL BE FILLED AT SITE.
STEEL TUBULAR LIGHTING POLE

LENGTH

6 OF HOLES FOR 10mm Ø BOLT
FOR MOUNTING OF BRACKET

DETAIL—'M'
FOR SWAGED POLE

30mm Ø HOLE ON POLE FOR WIRES LEADING TO LUMINAIRE

<table>
<thead>
<tr>
<th>POLE DESIGNATION</th>
<th>LENGTH(M) X+Y+Z=L</th>
<th>PLANTING DEPTH(M)</th>
<th>DIAMTHICKNESS BOTTOM(mm)</th>
<th>DIAM MIDDLE(mm)</th>
<th>DIAM TOP(mm)</th>
<th>WEIGHT OF POLE (Kg)</th>
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<tbody>
<tr>
<td>410 TP3/SP3</td>
<td>X+Y+Z=7</td>
<td>1.25</td>
<td>114.3x4</td>
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<td>78.1</td>
<td>87/85</td>
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<tr>
<td>410 TP12/SP12</td>
<td>X+Y+Z=8</td>
<td>1.5</td>
<td>114.3x4</td>
<td></td>
<td>78.1</td>
<td>101/97</td>
</tr>
<tr>
<td>410 TP13/SP13</td>
<td>X+Y+Z=8</td>
<td>1.5</td>
<td>139.7x4</td>
<td></td>
<td>88.9</td>
<td>125/119</td>
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<tr>
<td>410 TP27/SP27</td>
<td>X+Y+Z=9</td>
<td>1.5</td>
<td>114.3x4</td>
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<td>76.1</td>
<td>113/108</td>
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<tr>
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<td>139.7x4</td>
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<td>88.9</td>
<td>140/133</td>
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<tr>
<td>410 TP33/SP33</td>
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<td>165.1x4</td>
<td></td>
<td>114.3</td>
<td>170/184</td>
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</tbody>
</table>

NOTE:—
1. TP REFER TO STEPPED POLE.
2. SP REFER TO SWAGED POLE.
3. POLE DESIGNATION IS AS PER IS: 1239
SWAGED POLE TYPE 'B'

ELLiptical hole 30x60 for cable out let.

R=352

48Ø 3.25 thick

ELLiptical hole 30x60 for cable entry

Earthing stud with nut & 2 washers (GL)

25 185 10Ø hole

300 25

Welded with pole

57.5

Note:

1. All dimensions are in mm

Detail - D
SWAGED POLE TYPE 'C'
(FOR PLANT GROUND MOUNTING)

NOTES:

1. NIPPLE OF DIA. 45 (NIPPLE TO BE PREPD. BY DIRECT REDUCTION OF DIA OF TOP PIPE WITHOUT USE OF ANY WASHER)

2. POLE MATERIAL MS AS PER IS 1239 ABOVE GROUND PORTION TO BE PAINTED 2 COATS OF RED OXIDE PRIMER, UNDER GROUND PORTION PAINTED BITUMINUS PAINT.

3. FOR FLOOD LIGHTING POLE THE TOP PORTION NOT TO BE TILTED BUT A 300 x 300 x 6mm THICK M.S. PLATE WELDED AT THE TOP SHALL BE PROVIDED TO MOUNT FLOOD LIGHT.

4. ALL DIMENSIONS ARE IN mm
1. FOR PAD USE:—
   a) 400x400x70 CONCRETE BLOCK FOR POLES.
   b) BASE PLATE AS SHOWN IN PDS:E 205 FOR STEEL TUBULAR POLES
      SHALL BE USED AS PAD
   C) RCC / WOOD POLES DO NOT NEED ANY PAD.

2. MUFF IS MUST FOR STEEL TUBULAR POLES AND OPTIONAL FOR
   OTHERS POLES, MUFF SHALL BE PROVIDED AFTER UNDER GROUND
   CABLEING FOR STREET LIGHTING IS COMPLETED.

3. MUFF HEIGHT FROM GROUND LEVEL SHALL BE 300mm FOR ORDINARY
   POLES AND 457mm FOR STREET LIGHTING POLES HAVING J.B.LOCATED
   ON THE MUFF

4. FOR MOUNTING OF JBS’ ON THE MUFF REFER PDS:E 209

5. FOR PLANTING DEPTH REFER RELEVANT ISS.

6. ALL DIMENSIONS ARE IN mm
INSTALLATION ARRANGEMENT
STREET LIGHTING FIXTURES

M.S. TUBULAR POLE REFERENCE DRG. NO. PDS:E 203

30mm² HOLES FOR WIRES LEADING TO LUMINARIE WITH SUITABLE RUBBER GROMMET

G.LEV.

1250 FOR 7M HIGH POLE
1500 FOR 8M/9M HIGH POLE

400 SQ., 10TH. PAD/
BASE PLATE WELDED WITH M.S. TUBE

600 SQ.

50mm² G.I. PIPE

C.L OF 10mm² M.S. BOLT FOR FIXING JUNCTION BOX

NOTE :-
ALL DIMENSIONS ARE IN mm.
DETAILS OF BRACKET ARM
FOR STREET LIGHTING POLE

SECTION – XX

NOTES:

1. SIZE OF PIPE SHALL BE 30mm FOR TL/80W HPL FIXTURES,
   40mm FOR 70W SON/125W HPL FIXTURES AND 50mm FOR
   150W SON/250W HPL FIXTURES.

2. ALL DIMENSIONS ARE IN mm.
NOTES:—

1. SIZE OF G.I. PIPE SHALL BE 30mm FOR TL/80W HPL, 40mm FOR 70W SON/125W HPL AND 50mm FOR 150W SON//250W HPL FIXTURES.

2. THE CLAMP TO BE GROUTED IN BRICK WALL/RCC STRUCTURES, WELDED TO STEEL STRUCTURES.

3. USE 'U' TYPE CLAMPS FOR RAILING.

4. ALL DIMENSIONS ARE IN mm.
NOTE:—

1. THE MINIMUM INTERNAL DIMENSION OF THE J.B. SHALL BE 152 X 152 X 152.

2. THE FRONT DOOR SHALL BE HINGED & LOCKABLE TYPE.

3. THE CONNECTION OF FUSE TO THE PHASE 'R' IS TYPICAL ONE THE EXACT PHASE TO WHICH CONNECTION SHALL BE MADE SHALL BE DECIDED AT SITE.

4. FOR HAZARDOUS AREA'S THESE JUNCTION BOXES SHALL BE INCREASED SAFETY TYPE AND THE FUSE NEED NOT BE PROVIDED.

5. FOR POLE MOUNTED JUNCTION BOXED THE CABLE GLAND SHALL BE SIDE MOUNTED.

6. ALL DIMENSIONS ARE IN mm.
1. CONCRETING AND APPROVED MOUNTING HARDWARE FOR LIGHTING FIXTURES ARE INCLUDING IN SCOPE OF SUPPLY.

2. CONCRETE FOUNDATION OF GRADE M15 SHALL BE PROVIDED.

ALL DIMENSIONS ARE IN mm.
<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>MOTOR RATING IN KW</th>
<th>FULL LOAD CURRENT IN AMPS</th>
<th>STARTING CURRENT IN AMPS</th>
<th>MOTOR DUTY SWITCH RATING IN AMPS</th>
<th>FUSE RATING IN AMPS</th>
<th>CONTACTER RATING IN AMPS</th>
<th>THERMAL O/L RANGE IN AMPS.</th>
<th>CT. RATIO</th>
<th>POWER CABLE SIZE sq. mm (PVC/CPVC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.18</td>
<td>0.59</td>
<td>4.2</td>
<td>16</td>
<td>2</td>
<td>16</td>
<td>0.4–0.65</td>
<td>2/1</td>
<td>3x2.5(CU)</td>
</tr>
<tr>
<td>2.</td>
<td>0.25</td>
<td>0.88</td>
<td>6.3</td>
<td>16</td>
<td>4</td>
<td>16</td>
<td>0.6–1.0</td>
<td>2/1</td>
<td>3x2.5(CU)</td>
</tr>
<tr>
<td>3.</td>
<td>0.37</td>
<td>1.05</td>
<td>7.56</td>
<td>16</td>
<td>4</td>
<td>16</td>
<td>0.9–1.5</td>
<td>2/1</td>
<td>3x2.5(CU)</td>
</tr>
<tr>
<td>4.</td>
<td>0.55</td>
<td>1.50</td>
<td>10.8</td>
<td>16</td>
<td>6</td>
<td>16</td>
<td>1.4–2.3</td>
<td>2/1</td>
<td>3x2.5(CU)</td>
</tr>
<tr>
<td>5.</td>
<td>0.75</td>
<td>1.80</td>
<td>12.96</td>
<td>16</td>
<td>6</td>
<td>16</td>
<td>1.4–2.3</td>
<td>2/1</td>
<td>3x2.5(CU)</td>
</tr>
<tr>
<td>6.</td>
<td>1.10</td>
<td>2.50</td>
<td>18.0</td>
<td>16</td>
<td>10</td>
<td>16</td>
<td>2.3–3.0</td>
<td>5/1</td>
<td>3x2.5(CU)</td>
</tr>
<tr>
<td>7.</td>
<td>1.50</td>
<td>3.4</td>
<td>24.4</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>3.0–5.0</td>
<td>5/1</td>
<td>3x2.5(CU)</td>
</tr>
<tr>
<td>8.</td>
<td>2.20</td>
<td>4.60</td>
<td>33.1</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>4.5–7.5</td>
<td>5/1</td>
<td>3x2.5(CU)</td>
</tr>
<tr>
<td>9.</td>
<td>3.00</td>
<td>7.0</td>
<td>50.4</td>
<td>32</td>
<td>20</td>
<td>16</td>
<td>4.5–7.5</td>
<td>10/1</td>
<td>3x2.5(CU)</td>
</tr>
<tr>
<td>10.</td>
<td>3.70</td>
<td>7.3</td>
<td>52.5</td>
<td>32</td>
<td>20</td>
<td>16</td>
<td>6.0–10.0</td>
<td>10/1</td>
<td>3x2.5(CU)</td>
</tr>
<tr>
<td>11.</td>
<td>5.50</td>
<td>10.5</td>
<td>75.6</td>
<td>32</td>
<td>32</td>
<td>16</td>
<td>9.0–15.0</td>
<td>15/1</td>
<td>3x4(CU)</td>
</tr>
<tr>
<td>12.</td>
<td>7.50</td>
<td>14.0</td>
<td>100.8</td>
<td>63</td>
<td>32</td>
<td>16</td>
<td>9.0–15.0</td>
<td>20/1</td>
<td>3x6(CU)</td>
</tr>
<tr>
<td>13.</td>
<td>9.30</td>
<td>17.5</td>
<td>126.0</td>
<td>63</td>
<td>32</td>
<td>32</td>
<td>14.0–23.0</td>
<td>20/1</td>
<td>3x10(AL)</td>
</tr>
<tr>
<td>14.</td>
<td>11.0</td>
<td>20.6</td>
<td>148.3</td>
<td>63</td>
<td>63</td>
<td>32</td>
<td>14.0–23.0</td>
<td>25/1</td>
<td>3x10(AL)</td>
</tr>
<tr>
<td>15.</td>
<td>15.0</td>
<td>28.0</td>
<td>201.6</td>
<td>63</td>
<td>63</td>
<td>32</td>
<td>20.0–33.0</td>
<td>35/1</td>
<td>3x16(AL)</td>
</tr>
<tr>
<td>16.</td>
<td>18.5</td>
<td>33.0</td>
<td>237.6</td>
<td>100</td>
<td>80</td>
<td>40</td>
<td>30.0–50.0</td>
<td>40/1</td>
<td>3x25(AL)</td>
</tr>
<tr>
<td>17.</td>
<td>22.0</td>
<td>40.0</td>
<td>288.0</td>
<td>125</td>
<td>80</td>
<td>45</td>
<td>30.0–50.0</td>
<td>50/1</td>
<td>3x25(AL)</td>
</tr>
<tr>
<td>18.</td>
<td>30.0</td>
<td>52.0</td>
<td>374.4</td>
<td>125</td>
<td>100</td>
<td>70</td>
<td>45.0–75.0</td>
<td>60/1</td>
<td>3x35(AL)</td>
</tr>
<tr>
<td>19.</td>
<td>37.0</td>
<td>63.5</td>
<td>457.2</td>
<td>125</td>
<td>125</td>
<td>70</td>
<td>45.0–75.0</td>
<td>75/1</td>
<td>3x50(AL)</td>
</tr>
<tr>
<td>20.</td>
<td>45.0</td>
<td>76.0</td>
<td>557.2</td>
<td>200</td>
<td>160</td>
<td>110</td>
<td>66.0–110.0</td>
<td>100/1</td>
<td>3x70(AL)</td>
</tr>
<tr>
<td>21.</td>
<td>55.0</td>
<td>96.0</td>
<td>691.7</td>
<td>250</td>
<td>200</td>
<td>110</td>
<td>66.0–110.0</td>
<td>125/1</td>
<td>3x95(AL)</td>
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<tr>
<td>22.</td>
<td>67.5</td>
<td>119.0</td>
<td>858.0</td>
<td>250</td>
<td>200</td>
<td>200</td>
<td>90.0–150.0</td>
<td>125/1</td>
<td>3x150(AL)</td>
</tr>
<tr>
<td>23.</td>
<td>75.0</td>
<td>140.0</td>
<td>1008.0</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>MICROPROCESSOR RELAY</td>
<td>150/1</td>
<td>3x185(AL)</td>
</tr>
<tr>
<td>24.</td>
<td>90.0</td>
<td>156.0</td>
<td>1123.2</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>MICROPROCESSOR RELAY</td>
<td>175/1</td>
<td>3x240(AL)</td>
</tr>
<tr>
<td>25.</td>
<td>110.0</td>
<td>192.0</td>
<td>1382.4</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>MICROPROCESSOR RELAY</td>
<td>225/1</td>
<td>3x300(AL)</td>
</tr>
<tr>
<td>26.</td>
<td>125.0</td>
<td>217.0</td>
<td>1627.5</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>MICROPROCESSOR RELAY</td>
<td>250/1</td>
<td>3x400(AL)</td>
</tr>
<tr>
<td>27.</td>
<td>132.0</td>
<td>234.0</td>
<td>1684.8</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>MICROPROCESSOR RELAY</td>
<td>250/1</td>
<td>3x400(AL)</td>
</tr>
<tr>
<td>28.</td>
<td>160.0</td>
<td>279.0</td>
<td>2008.8</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>MICROPROCESSOR RELAY</td>
<td>300/1</td>
<td>3x185(AL)</td>
</tr>
<tr>
<td>29.</td>
<td>180.0</td>
<td>304.0</td>
<td>2188.8</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>A.C.B.</td>
<td>MICROPROCESSOR RELAY</td>
<td>350/1</td>
<td>2–3x240(AL)</td>
</tr>
</tbody>
</table>

**NOTE:**

1. THE ABOVE DATA IS APPLICABLE FOR 415V, 4 POLE MOTORS.

2. AMMETERS SHALL HAVE UNIFORM SCALE UPTO C.T. PRIMARY CURRENT AND COMPRESSED END SCALE UPTO SIX TIMES THE C.T. PRIMARY CURRENT.

3. POWER CABLE SIZE SHALL BE SUBJECT TO VOLTAGE DROP CHECK.
NOTE:—

CONTACTORS C1, C2 AND C3 CONTROLS THE LIGHTING FEEDERS FOR NORMAL, EMERGENCY AND D.C. SUPPLY RESPECTIVELY.
NOTES:

1. THE TOP OF TRENCH SHALL MATCH THE FLOOR LEVEL IN PLANT AREA.
2. IN INDOORS INSTEAD OF RCC SLAB, 20MM THICK AL. EXTRUDED PLANK OR 10MM THICK M.S. CHEQUERED PLATE SHALL BE USED AS PER PDS:E 507.
3. PROPER SLOPE TO BE GIVEN IN THE TRENCH FOR NATURAL DRAINAGE.
4. SS—SINGLE SIDE CABLE SUPPORTS.
5. DS—DOUBLE SIDE CABLE SUPPORTS.
6. ALL DIMENSIONS ARE IN mm.
CABLE RACK ARRANGEMENT IN TRENCHES

SECTION OF TRENCH

<table>
<thead>
<tr>
<th>DESIGN TYPE</th>
<th>X</th>
<th>Y</th>
<th>N</th>
<th>M</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>5T–350–DS.</td>
<td>1400</td>
<td>1500</td>
<td>400</td>
<td>650</td>
<td>350</td>
</tr>
<tr>
<td>4T–350–DS.</td>
<td>1400</td>
<td>1200</td>
<td>250</td>
<td>650</td>
<td>350</td>
</tr>
<tr>
<td>3T–350–DS.</td>
<td>1400</td>
<td>900</td>
<td>250</td>
<td>300</td>
<td>350</td>
</tr>
<tr>
<td>5T–350–SS.</td>
<td>1000</td>
<td>1500</td>
<td>400</td>
<td>650</td>
<td>350</td>
</tr>
<tr>
<td>4T–350–SS.</td>
<td>1000</td>
<td>1200</td>
<td>250</td>
<td>650</td>
<td>350</td>
</tr>
<tr>
<td>3T–350–SS.</td>
<td>1000</td>
<td>900</td>
<td>250</td>
<td>300</td>
<td>350</td>
</tr>
<tr>
<td>5T–250–DS.</td>
<td>1200</td>
<td>1500</td>
<td>400</td>
<td>650</td>
<td>250</td>
</tr>
<tr>
<td>4T–250–DS.</td>
<td>1200</td>
<td>1200</td>
<td>250</td>
<td>650</td>
<td>250</td>
</tr>
<tr>
<td>3T–250–DS.</td>
<td>1200</td>
<td>900</td>
<td>250</td>
<td>300</td>
<td>250</td>
</tr>
<tr>
<td>5T–250–SS.</td>
<td>900</td>
<td>1500</td>
<td>400</td>
<td>650</td>
<td>250</td>
</tr>
<tr>
<td>4T–250–SS.</td>
<td>900</td>
<td>1200</td>
<td>250</td>
<td>650</td>
<td>250</td>
</tr>
<tr>
<td>3T–250–SS.</td>
<td>900</td>
<td>900</td>
<td>250</td>
<td>300</td>
<td>250</td>
</tr>
</tbody>
</table>

NOTES:
1. SS—SINGLE SIDE CABLE SUPPORT.
2. DS—DOUBLE SIDE CABLE SUPPORT.
3. ALL DIMENSIONS ARE IN mm.
NOTE:—

1. CABLE SLITS SHALL BE FILLED WITH SAND AND PROPERLY PLASTERED WITH LEAN CONCRETE AFTER LAYING OF CABLES.

2. WHEREVER CABLES ARE COMING OUT OF THE SLIT, SUITABLE MECH.PROTECTION TO BE PROVIDED.
NOTE:–
THICKNESS " T " SHALL BE 3mm FOR G.I AND 4mm FOR AL.
Plan

<table>
<thead>
<tr>
<th>Design Type</th>
<th>W</th>
<th>X=R+W+125</th>
<th>Z=2R+W+250</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT 900</td>
<td>900</td>
<td>1725</td>
<td>2550</td>
</tr>
<tr>
<td>HT 600</td>
<td>600</td>
<td>1425</td>
<td>2250</td>
</tr>
<tr>
<td>HT 450</td>
<td>450</td>
<td>1275</td>
<td>2100</td>
</tr>
<tr>
<td>HT 300</td>
<td>300</td>
<td>1125</td>
<td>1950</td>
</tr>
</tbody>
</table>

Notes:
1. Distance between two rungs should be approx. 300mm.
2. All dimensions are in mm.
NOTES:

1. DISTANCE BETWEEN TWO RUNGS SHOULD BE APPROX. 300mm.
2. ALL DIMENSIONS ARE IN mm.
PRE-FABRICATED CABLE TRAY
90° HORIZONTAL BENDS

PLAN
(700R BEND)

PLAN
(300R BEND)

SECTION A-A

ALL DIMENSIONS ARE IN mm.
DIMENSIONS ARE IN mm.
PRE-FABRICATED CABLE TRAY
90° VERTICAL BENDS
BENDING RADIUS 600 mm

VERTICAL 90° BEND IN SIDE

VERTICAL 90° BEND OUT SIDE

ALL DIMENSIONS ARE IN mm.
PRE-FABRICATED CABLE TRAY
COUPLING ARRANGEMENT

SECTION A–A

STRAIGHT RUN

10 Ø HOLE

210 x 80 x 4 THICK
STRAIGHT COUPLER PLATE

8 Ø BOLT WITH NUT
& WASHER

185 x 80 x 4 THICK COUPLER PLATE

100 x 80 x 4 THICK COUPLER PLATE

4 THICK WASHER TO BE USED ONE
THIS SIDE ONLY TO MAINTAIN SURFACE

PLAN
(VIEW FORM B–B)

ELEVATION
(ADJUSTABLE BEND)

15 DIA. HOLE (TO BE FIXED BY 12 DIA.
BOLT WITH NUT & WASHER

ALL DIMENSIONS ARE IN mm.
NOTES:—

1. HORIZONTAL RUN TO BE CLAMPED WITH EVERY SUPPORT AS PER LAYOUT
2. VERTICAL RUN/ RISER TO BE CLAMPED WITH EVERY SUPPORT AS PER LAYOUT
3. EACH CRANK HOOK SHALL BE SUPPLIED WITH ONE PLAIN WASHER, ONE SPRING WASHER AND TWO DOUBLE CHAMFERED HEX NUTS. THESE SHALL BE GALVANISED ITEMS.
4. ALL DIMENSIONS ARE IN mm.
PRE-FABRICATED CABLE TRAY
REDUCING COUPLER PLATE

PLAN
(REDUCING TRAY JOINT)

DETAIL - X
DETAIL OF REDUCING COUPLER PLATE (4 THICK)

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>W1</th>
<th>W2</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>900</td>
<td>600</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>450</td>
<td>450</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>600</td>
<td>450</td>
<td>150</td>
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<td></td>
<td>300</td>
<td>150</td>
<td>300</td>
</tr>
<tr>
<td>3</td>
<td>450</td>
<td>300</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>300</td>
<td></td>
</tr>
</tbody>
</table>

ALL DIMENSIONS ARE IN mm.
<table>
<thead>
<tr>
<th>SL. No.</th>
<th>EQUIPMENT TO BE EARTHED</th>
<th>FAULT LEVEL (MVA)</th>
<th>G.I. STRIPS/WIRES</th>
<th>ALUMINIUM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>MIN. SIZE (mm²)</td>
<td>SIZE TO BE USED (mm²)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2–50x8</td>
<td>2–38.1x6.35=484</td>
</tr>
<tr>
<td>1A</td>
<td>FOR PLANTS HAVING SWITCHYARDS/GENERATING STATION</td>
<td>750 AT 11KV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.</td>
<td>SWITCH YARD EQUIPMENT, GENERATORS, H.T. SWITCH BOARDS, TRANSFORMERS, MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II.</td>
<td>SWITCH YARD EQUIPMENT, GENERATORS, H.T. SWITCH BOARDS, TRANSFORMERS, MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.</td>
<td>500 AT 11KV</td>
<td>60x8</td>
<td>328</td>
</tr>
<tr>
<td>III.</td>
<td>SWITCH YARD EQUIPMENT, GENERATORS, H.T. SWITCH BOARDS, TRANSFORMERS, MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.</td>
<td>250 AT 6.6KV 125 AT 3.3KV</td>
<td>50x8</td>
<td>272</td>
</tr>
<tr>
<td>IV.</td>
<td>SWITCH YARD EQUIPMENT, GENERATORS, H.T. SWITCH BOARDS, TRANSFORMERS, MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.</td>
<td>350 AT 11KV 200 AT 6.6KV 100 AT 3.3KV</td>
<td>50x8</td>
<td>229</td>
</tr>
<tr>
<td>V.</td>
<td>SWITCH YARD EQUIPMENT, GENERATORS, H.T. SWITCH BOARDS, TRANSFORMERS, MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.</td>
<td>250 AT 11KV 150 AT 6.6KV 75 AT 3.3KV</td>
<td>50x6</td>
<td>163</td>
</tr>
<tr>
<td>1B</td>
<td>FOR PLANTS WITHOUT SW.YARD/GENERATING STN. H.T.SWITCH BOARDS, TRANSFORMERS, MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.</td>
<td>ANY FAULT LEVEL AT ANY VOLTAGE</td>
<td>50x6</td>
<td>120</td>
</tr>
<tr>
<td>1C</td>
<td>ALL M.V.SWITCH BOARDS</td>
<td>210 50x6</td>
<td>120</td>
<td>38.1x3.18=121</td>
</tr>
<tr>
<td>2</td>
<td>H.V. MOTORS</td>
<td>210 50x6</td>
<td>120</td>
<td>38.1x3.18=121</td>
</tr>
<tr>
<td>3</td>
<td>TRANSFORMER NEUTRALS</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>4</td>
<td>M.V. MOTORS RATED 75KW &amp; ABOVE</td>
<td>210 50x6</td>
<td>120</td>
<td>38.1x3.18=121</td>
</tr>
<tr>
<td>5</td>
<td>M.V. MOTORS ABOVE 30KW &amp; LESS THAN 75KW</td>
<td>175 35x6</td>
<td>93</td>
<td>31.75x3.18=101</td>
</tr>
</tbody>
</table>

REMARKS: – DO –
<table>
<thead>
<tr>
<th>SL. No.</th>
<th>EQUIPMENT TO BE EARTHED</th>
<th>FAULT LEVEL (MVA)</th>
<th>G.I. STRIPS/WIRES</th>
<th>ALUMINIUM</th>
<th>1.1kV PVC SINGLE CORE CABLE</th>
<th>REMARKS</th>
</tr>
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<tr>
<td>6</td>
<td>M.V.MOTORS ABOVE 5.5KW &amp; LESS THAN 30KW 63A SW.SOCKETS,BATTERY CHARGERS,LIGHTING SUB-DIST.BDS.,D.C.BDS.</td>
<td>44</td>
<td>25x6</td>
<td>25</td>
<td>2 SWG=38.6 17 25 29</td>
<td>AS PER CLAUSE 12.3.2 OF IS:3043</td>
</tr>
<tr>
<td>7</td>
<td>M.V.MOTORS RATED 5.5KW &amp; BELOW</td>
<td>7</td>
<td>8 SWG=13</td>
<td>5</td>
<td>10 SWG=8.3 18 6 30</td>
<td>-00-</td>
</tr>
<tr>
<td>8</td>
<td>ALL MINOR EQUIPMENT RATED FOR 250V &amp; BELOW</td>
<td>-</td>
<td>10 SWG=8.3</td>
<td>-</td>
<td>10 SWG=8.3 18 6 30</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>NON ELECTRICAL EQUIPMENT,SUCH AS VESSELS STRUCTURES IN HAZARDOUS AREA &amp; LIGHTNING PROTECTION CONDUCTORS</td>
<td>32x6</td>
<td>35x6</td>
<td>-</td>
<td>25.4x3.18=81 16 - -</td>
<td>AS PER IS:2309</td>
</tr>
</tbody>
</table>

NOTE:—EARTHING CODUCTOR SIZES FOR ITEMS AT SL.No.4,5,6 & 7 SHOULD BE CHOSEN AS HALF THE POWER CABLE SIZES ACTUALLY USED.
' T ' JOINT ALUMINIUM STRIP TO ROUND ALUMINIUM CONDUCTOR

' T ' JOINT G.I. STRIP TO ROUND ALUMINIUM CONDUCTOR
ARRANGEMENT OF CONNECTIONS OF EARTH CONDUCTORS
(TERMINATION OF ROUND EARTH CONDUCTOR AT EQUIPMENT)

STAINLESS STEEL BOLTS & NUTS
WITH SS WASHER & SPRING WASHER
FOR EARTHING ON EQUIPMENT

EQUIPMENT

AL SOLDERLESS (CRIMPING)
SOCKET SUITABLE FOR WIRE SIZE

EARTHING CONDUCTOR
(AL ROUND WIRE)

GRAPHITE GREASE TO BE
APPLIED AT MATING SURFACES
BEFORE FIXING THE BOLT. SHADED PORTION
TO BE PAINTED WITH EPOXY RESIN
PAINT AFTER CLEANING THE EXCESS GREASE

ARRANGEMENT OF DOUBLE EARTH CONNECTIONS TO EQUIPMENT

WASHERS

STUD

SOCKET

EARTHING CONDUCTOR

EQUIPMENT

VIEW FROM D
HATCHED PORTION TO BE PAINTED
WITH BITUMINOUS PAINT AND TAPPED
WITH BITUMINOUS HESIAN TAPE AFTER
WELDING TO PREVENT CORROSION

WELDED JOINT
(OVER LAP MIN. 100mm)

G.I. STRIP

STRAIGHT JOINT G.I TO G.I. STRIP

WELDED JOINT

ALUMINIUM STRIP SHOULD BE CLEANED
BEFORE WELDING THE COMPLETED JOINT
SHOULD BE PAINTED WITH EPOXY

WELDED JOINT
(OVER LAP MIN 100mm)

RESIN PAINT

ALUMINIUM STRIP

STRAIGHT JOINT AL. TO AL. STRIP

" T " JOINT G.I. TO G.I. STRIP

" T " JOINT AL TO AL STRIP
GRAFITE GREASE TO BE APPLIED AT MATCHING SURFACES BEFORE FIXING THE BOLT. SHADED PORTION TO BE PAINTED WITH EPOXY RESIN PAINT AFTER CLEANING THE EXCESS GREASE.

ALUMINIUM STRIP (OVERLAP MIN. 150mm)

M14x40 LONG STAINLESS STEEL BOLTS AND NUTS WITH S.S. WASHER & SPRING WASHER

ARRANGEMENT OF LAP JOINT BETWEEN AI. EARTH STRIP TO G.I. EARTH STRIP
NOTE:

EPoxy Resin PILate shall be used for AL strip and BITUMINOUS paint for GI strip.
"T" JOINT ROUND ALUMINIUM CONDUCTOR TO ROUND ALUMINIUM CONDUCTOR (CRIMPING TYPE)

NOTE:

USE CORRECT SIZE OF COMPRESSION DIES.
GROOVE FOR PLACING R.C.C. COVER ON EARTH PIT

G.I. "L" SHAPED CONNECTING TEST LINK WITH BOLTS
FOR CONNECTING TO EARTH PIPE

G.I. BRACKET FOR TEST LINK TO BE GROUTED
TO THE WALL WITH RAG BOLTS & NUTS

TO NEXT EARTH PIT (G.I. STRIP)

BRICK WALL ALL AROUND PIT
TO BE MADE AFTER ALL
CONNECTIONS ARE COMPLETED

8Ø X25 LONG G.I. ROOFING BOLTS
WITH NUTS AND WASHERS

FOR DETAILS OF BOLTED JOINT BETWEEN AL & G.I.
REFER PDS:E 603 (SHEET 4 OF 6)

G.I. EARTH ELECTRODE AS PER DRG. NO. PDS:E 610
EARTH PIT DETAIL AS PER DRG. NO. PDS:E 605
AND ACCESSORIES AS PER DRG. NO. PDS:E 611

TO EQUIPMENT / SYSTEM EARTH BUS
(G.I. STRIP). INSTEAD OF G.I. STRIP, PVC INSULATED CABLE MAY ALSO BE USED & CONNECTED TO THE G.I. BRACKET BY USING AL. CABLE SOCKET.
SECTIONAL ELEVATION OF EARTH PIT

R.C.C. COVER

RECESS FOR LIFTING

BRICK WORK

G.I. STRIP TO NEXT ELECTRODE

G.I. STRIP TO NEXT ELECTRODE

8x25 LONG G.I. ROOFING BOLTS WITH NUTS & WASHER

FILLED UP WITH EARTH

100NB HEAVY G.I. PIPE AS PER IS: 1239

AT EVERY 75 Ø OF 12Ø HOLES

FILLED UP WITH ALTERNATE LAYERS OF COKE 450mm & COMMON SALT 150mm

PC009
TYPICAL ARRANGEMENT OF EARTHING FOR MOTOR AND START STOP PUSH BUTTON STATION

PVC INSULATED CONDUCTOR/ GI.WIRE/ AL. WIRE FOR EARTHING OF MOTOR

POWER CABLE

2NOS. EARTHING CONDUCTORS

POWER CABLE

CONTROL CABLE

CABLE CLAMPING ARRANGEMENT

100X50 M.S. CHANNEL FOR SUPPORTING CABLE, LOCAL CONTROL STN.

HOSE PROOF/DUST PROOF LOCAL CONTROL STN.

PVC INSULATED CONDUCTOR/GI. WIRE/ AL. WIRE FOR EARTHING OF L.C.S.

VIEW AT—A

MOTOR TERMINAL BOX

EARTH TERMINALS—TERMINATION OF AL. CONDUCTOR THROUGH AL. CABLE SOCKET

(For details Refer PDS:E 603 SH.2)

200x200x10 THICK PLATE GROUTED Flush WITH FINISH FLOOR LEVEL

50X6 FLATS WELDED TO THE CHANNEL @ 300 INTERVAL

RUBBER BUSHING
TYPICAL ARRANGEMENT OF EARTHING FOR MOTOR AND START STOP PUSH BUTTON STATION

FOR TERMINATION DETAILS,
(REF. PDS:E 603 SHEET 5 OF 6)

SOCKET
(FOR DETAILS REF. DRG. NO. PDS:E 603 SHEET 2 OF 6)

ROUND G.1/AL. CONDUCTOR TO LOCAL CONTROL STATION

G.1/AL. EARTH STRIP FROM CABLE TRENCH

FOR CONNECTION OF G.1/AL. WIRE WITH G.1/AL. STRIP.
(REF. PDS:E 603 SHEET 1 OF 6)

G.1/AL. EARTH STRIP FROM CABLE TRENCH

CABLE AND STRIP PROTECTIONPIPE FROM TRENCH
NOTE:—

1. 12Ø Holes will be provided at 75mm interval on two faces throughout the length of pipe. The first one shall start 700mm below the welded flat.

2. All dimensions are in mm.
HOLES SUITABLE FOR 8mmØ GI ROOFING BOLTS

HOLES SUITABLE FOR 12Ø (M14) BOLTS

CONNECTING TWISTED ALUMINIUM FLAT PIECE

HOLES SUITABLE FOR 8mmØ GI ROOFING BOLTS

HOLES SUITABLE FOR 12Ø (M14) BOLTS

CONNECTING ALUMINIUM / G.I. FLAT PIECE
THE NO. OF EARTH CONDUCTOR SHALL BE AS FOLLOWS

<table>
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<tr>
<th>EQUIPMENT WITH ANY DIMENSION</th>
<th>HAZARDOUS AREA</th>
<th>NON-HAZARDOUS AREA</th>
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<tr>
<td>≤ 3 Mts.</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 3 Mts. ≤ 30 Mts.</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 30 Mts.</td>
<td>3</td>
<td>2</td>
</tr>
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</table>
G.I. EARTH BUS

50 x 12 G.I. FLAT

50 x 12 G.I. FLAT

EARTHING HOLES SUITABLE FOR M8 BOLTS

ELEVATION

PLAN

FIXING HOLES SUITABLE FOR M14 BOLTS

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<tr>
<th>TYPE OF EARTH BUS</th>
<th>NO. OF EARTHING HOLES</th>
<th>OVERALL LENGTH x (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>335</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>390</td>
</tr>
</tbody>
</table>

NOTES:

1. LOCATION OF EARTH BUS TO BE DECIDED AS PER EQUIPMENT POSITION AT SITE.
2. EARTH BUSES SHALL BE LOCATED ON STRUCTURES/COLUMNS/WALLS/EQUIPMENT FOUNDATION ETC.
3. MOUNTING HEIGHT OF EARTH BUS SHALL NOT BE LESS THAN 500mm FROM FINISHED FLOOR LEVEL
4. ALL DIMENSIONS ARE IN mm
SECTION VI – 5.5

DESIGN PHILOSOPHY - CIVIL & STRUCTURAL WORKS

PLANT: STEAM GENERATION PLANT

PROJECT: INTEGRATED COAL BASED FERTILISER COMPLEX AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA)
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<td>ES-2516 : TECHNICAL SPECIFICATION FOR CIVIL,</td>
<td>(Annexure-V)</td>
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## 2.0 DETAILED ENGINEERING

2.1 General
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3.0 **CONSTRUCTION**

3.1 General

4.0 **QUALITY ASSURANCE PLAN**

5.0 **COMPLETENESS OF WORK CONTRACT**
GENERAL DESCRIPTION OF SCOPE

This section of the Tender Documents deals mainly with the Scope and Technical Specifications needed for the design, preparation of detailed Drawings and getting the design/ drawings approved by Owner/Consultant, execution and construction of complete Civil, Structural and other Allied Works on turnkey basis.

The scope of Civil Structural and Architectural Works under this Contract shall include carrying out Grading & Leveling, Detailed Design, Drawings, Supply, Procurement of all materials, Construction, Demolitions, Supervision of all relevant Civil and Structural Works including providing all labour, supervision, material, scaffolding, construction equipment, tools, tackles and plants, supplies, transportation, all incidental items though not indicated or specified but reasonably implied or necessary for successful completion of the project. The tentative sizes of various process units, utilities and storage facilities are provided in the Plot Plan. Scope of the CONTRACTOR shall include but not limited to the following:-

a) Engineering related to site leveling & preparation.
b) Soil Investigation, if required.
c) Preparation of concept notes for design, engineering & construction.
d) Structural Analysis and design calculations as per specifications laid down in Civil Engineering Design Basis, enclosed in the tender. for all Civil works including but not limited to pile, pile-cap, foundation, plinth beam, RC superstructure, steel super structure, trenches, drains, pits etc.
e) Architectural design and drawings including details for doors, windows, partitions, false floor, false ceiling, toilet, finishes etc.
f) General Arrangement and detail design drawings for pile, pile-cap, foundations, plinth beams etc, based on the soil investigation carried out by the bidder for the proposed site.
g) General Arrangement and structural drawings at grade level showing foundations, extent of paving, trenches, drains, pits etc.
h) General Arrangement and detail design drawings for superstructure (RCC and structural steel) at all levels.

i) RCC drawings showing all necessary details for all foundations and structures.

j) Structural steel detail drawings for all steel structures.

k) General Arrangement and detail drawings for access roads, storm water drains, effluent drains, cable trenches, sewerage, manholes, pits, sumps with all necessary details.

l) Effluent Treatment Plant (having zero liquid discharge) and Sewage treatment plant within battery limit.

m) Bar Bending Schedules for all RCC works.

n) Fabrication drawings with all details for steel structures.

o) Coordination with OWNER / PMC for various activities including approvals of design basis, concept note, drawings, material samples, laboratory test results etc.

p) Procurement of all items necessary for completion of scope of work.

q) Construction of all units / structures, items of work included in scope of work.

r) Preparation of as built drawings & final documentation.

s) Obtaining Statutory Approvals.

t) Adherence to Quality Assurance Plan

1. DETAILED SCOPE OF WORK

1.1. Soil Investigation

1.1.1 The CONTRACTOR shall carryout detailed soil investigation for the proposed plant afresh.

1.1.2 The CONTRACTOR shall adopt pile foundation, open type isolated, raft foundations as per foundation requirements of structure, loads, settlement & other design criteria.

1.1.3 The CONTRACTOR shall design and construct all foundations as per requirements with no extra cost to OWNER / Project Management Consultant (PMC).
1.2 **Topographical / Contour Survey**

The Topographical Survey report of plant area is attached with the Tender for reference. However, the CONTRACTOR may carry out his own Topographical investigation afresh if required.

Before commencement of work / Contour Survey, the CONTRACTOR shall clear the site from all the debris lying on the site.

At bidding stage, the CONTRACTOR shall visit the site and study the existing site conditions & existing structures if any.

1.2.1 **Site Conditions**

Levels like Finished Ground Level (FGL) and Highest Point of Paving (HPP) shall be finalized by the CONTRACTOR in consultation with OWNER / PMC based on contour survey of the unit, levels of adjacent units and levels of adjacent roads.

1.3 **Grading**

Fairly graded land site shall be provided to the CONTRACTOR. However, micro grading works shall be in CONTRACTOR’s scope. The CONTRACTOR shall establish the finished grade levels of buildings after studying the existing site conditions, high flood level so as to maintain proper efficient drainage of the plant area at no extra cost to OWNER / PMC. These grade levels shall be approved by the OWNER / PMC.

Wherever filling / cutting is involved stone pitching should be provided as slope protection to protect the areas.

1.4 **Disposal of surplus earth**

The CONTRACTOR shall dispose-off all surplus and unserviceable earth (if any), outside the plant in accordance to local Governing authority, at his own cost.

Disposal shall be done at a place outside the plant, with the consent of the OWNER. Location of disposal area shall be decided by the CONTRACTOR and the required necessary approvals from the local bodies shall be the CONTRACTOR’s responsibility.

1.5 **Site cleaning**
During construction and on completion of construction (inclusive all internal and external finishes), cleaning all the debris, waste materials scattered in and around the site and disposal of the same shall be in the scope of the CONTRACTOR with the consent of the OWNER.

1.6 **Roads**

The CONTRACTOR shall be responsible for complete planning and construction of the roads for access to all buildings and units of the plant (under his scope) from the existing roads including necessary tie-in connections. All works associated with shifting of Roads and related services (e.g. all type of drainages, culverts etc.) as required, for the proposed site, shall be in the scope of contractor.

1.7 **Surface Drainage**

The scope of work includes also providing all internal services such as water supply, sanitary sewerage, drainage and storm water drains etc. and connection to external prevailing facilities complete in all respects. All the above work shall be carried out strictly in accordance with the "Technical Specifications (ES-2517)" enclosed with the tender.

The CONTRACTOR shall ensure proper drainage of all components of the Plant. For the purpose of drainage the Contractor’s scope is not limited only up to the Unit Battery Limit but shall extend up to the adjacent drainage network around the unit. The CONTRACTOR shall provide proper drainage system for all roads mentioned in the above Para 1.6. Storm Water Drains shall be connected to the existing drainage system by providing suitable tie-in points.

The CONTRACTOR shall study the existing drainage system as per actual site conditions. Tie-in points for drainage & sewer shall be manhole / chamber (under bidder’s scope) may be located at the outer boundary of bidders battery limit as per direction of Owner/PMC. The CONTRACTOR shall decide tie-in points for storm water drain based on existing drainage system in consultation with OWNER and PMC during detail engineering.

The drainage system shall be by gravity. Storm water drains shall be sized for the peak discharge arising discharge arising out of either rain water or fire fighting water.
1.8 **Contaminated Rain Water System and Oily Water Sewer (OWS) System**

The CONTRACTOR shall provide proper underground drainage system for contaminated rain-water and OWS. These shall be as per the philosophy mentioned in this tender document or in consultation with PMC/OWNER. The treated oily water shall be pumped to Owner's Guard Pond. Details of Tie-in points at battery limit shall be provided during detail design stage.

1.9 **Sewage Disposal Scheme**

The CONTRACTOR scope is to provide proper underground drainage system for sewage disposal and its connection to Common Sewage treatment plant for whole complex.

1.10 **Paving**

The CONTRACTOR shall provide RCC pavement for the complete area of the plant as job specific requirement. For the purpose of paving the Contractor's scope is not limited only up to Battery Limit, but shall extend up to the adjacent roads around the unit.

1.11 **Structures buildings etc.**

Contractor's scope shall include various technological structures steel & R.C.C. structures, pipe rack, buildings, equipment foundations, pits, cable trench, sheds, etc. as per the approved Plot Plan or mentioned in this tender document, required for the complete execution and commissioning of the plant.

1.12 **Surface Finishing's**

The CONTRACTOR shall be responsible for complete planning and detailing of all surfaces finishes viz. painting, flooring etc as per specifications given in the Tender.

1.13 **Acid / Alkali Proof Lining**

The CONTRACTOR shall be responsible for surface treatment of floors, exposed portion of foundations, pits and basins against acid / alkali as per process requirement.

1.14 **Anti-termite Treatment / Damp proof course / Water proofing**

The CONTRACTOR shall provide anti-termite treatment, damp proof course and water proofing as per design basis. Water proofing (for all open terraces) of all
buildings shall be done by water proofing PU coating with treatment also, of approved Brand and make.

1.15 Miscellaneous
These shall include local platforms, pipe sleepers, local foundations, local supports, etc. as per requirement.

1.16 Engineering and construction
Preparation of detailed design, drawings, supply and construction of all civil, structural, architectural, plumbing & sanitary and building works shall be in the scope of contractors work.

1.17 Removal of Underground and Above Ground Structures
All above ground and underground structures will be demolished by the Owner. Underground facilities/structures, if any, demolished/ removed by the Contractor should ensure removal of former will not disturb the functions of existing plant, if any.

Demolition/Removal/Rerouting of cables / pipes, etc. encountered during excavation in the plot shall be in Bidder’s scope of work. Existing piles if any, needs to be adjusted while making new piling/foundations.

1.18 Transfer of benchmark
The Benchmark will be made available inside plant premises. However, it may be verified by CONTRACTOR.

1.19 Sizing of various facilities
Sizing, nos., location etc. of various facilities viz. buildings, pipe rack, structures, equipments, etc. shall be in the scope of the bidder.

Any change of sizing, addition of any structure / facility, indicated by Owner/PMC during design stage, based on functional requirements and as well as local rules and regulations, etc, shall be in the Contractor’s scope, at no extra cost to OWNER / PMC.

1.20 Scope of work in outside battery limit (OSBL) Area
Scope includes work in OSBL area, if required, such as pipe racks, local platforms, local supports, road crossings / culverts from tie-in points to new units.
1.21 **Rules and regulations**

All the facilities shall conform to all Local Rules and Regulations, Factory Inspector, Rules, TAC rules etc. whichever is more stringent.

Getting the approval of the various documents through the various authorities shall be in the Contractor’s scope at no extra cost to OWNER / PMC.

2.0 **DETAILED ENGINEERING**

2.1 **General**

2.1.1 The CONTRACTOR shall carryout Analysis and Design of the structures required for this document and shall prepare all the required Architectural, Civil and Structural drawings needed for correct and accurate construction as per the Design Specifications given in this document.

2.1.2 The CONTRACTOR shall submit a Detailed Schedule for release of documents and drawings for review / approval to PMC/OWNER, within 2 weeks/or mutually period of date of award of the Contract. Such a schedule shall be made in line with the overall Project Schedule given in the document. The CONTRACTOR shall strictly adhere to the approved schedule.

The Format of Submission of the above mentioned schedule shall be mutually discussed and finalized after award of the job.

2.1.3 Construction of various structures / facilities, whose designs and / or drawings are specially identified in the Document Control Index or Project Schedule for approval by PMC/OWNER, shall not be taken up for construction at site till they are approved by PMC/OWNER and comments given are incorporated.

For other structures / facilities, the CONTRACTOR shall directly submit the Approved for Construction (AFC) drawings to PMC for information before, taking up construction.

2.1.4 It shall be the responsibility of the CONTRACTOR to accommodate all the functional requirements such as access, cutouts, clearances, interference etc. while designing / detailing of various structures / facilities.

2.1.5 Complete analysis, design and all drawings (including all soft files of drawings & design sheets) of each independent structure / facility shall be submitted in one lot so as to facilitate overall systematic review by PMC.
2.1.6 Only after the necessary architectural drawings are approved by the OWNER / PMC to their satisfaction, then the design drawings shall be reviewed and approved by PMC.

2.1.7 The CONTRACTOR shall keep the OWNER / PMC informed of any major design revisions simultaneously in progress.

2.2 Design calculations

The CONTRACTOR shall prepare the design calculations based on the standard accepted practice and guidelines from PMC / OWNER.

All design calculations shall be written systematically, legibly and submitted for approval as per standard accepted practice.

For structures, analysis and design shall be done on latest version of STAADPRO SOFTWARE.

For other miscellaneous works Excel and Word shall be used. Design calculations shall be done on A4 size sheet only.

2.3 Drawings

The CONTRACTOR shall prepare

- Civil & structural design & construction drawings, architectural drawings based on the standard accepted practice and guidelines from PMC / OWNER.

- Bar bending schedules.

- Fabrication drawings.

- As-built drawings.

- Detailing / drafting shall be done on AUTOCAD Latest Version only. Drawing size used shall be preferably of A1 size only. For foundation layout, drainage plans and paving plans, A0 size drawings can be used if necessary.

3.0 CONSTRUCTION

3.1 General

3.1.1 Construction of all civil and structural works including all material, labour,
Supervision, tools and tackles etc. shall be carried out by the CONTRACTOR

3.1.2 Procurement and supply of all materials viz. cement, reinforcement, structural steel etc. shall be in the scope of CONTRACTOR.

3.1.3 All materials shall be procured in consultation with the Owner or as per the approved vendor list given elsewhere in this document. All materials of construction must be of ISI approved brand.

3.1.4 All materials and construction shall confirm to the specification given elsewhere in this document.

3.1.5 Materials of construction, construction methodology etc. shall be such, so as to protect the structures and foundations against the harmful effect of chemical, fumes etc. present in the plant, its vicinity, in ground and / or subsoil water.

3.1.6 The CONTRACTOR shall be responsible for obtaining the statutory approval from local authorities such as Inspector of Factories, Development Authorities, Municipal Corporation and other concerned authorities before starting the work.

3.1.7 The CONTRACTOR shall ensure that the facilities are constructed in accordance with the APPROVED FOR CONSTRUCTION drawings and specifications.

3.1.8 The CONTRACTOR shall maintain and operate an adequate system of control of availability of latest drawings and specifications, at all the places where work is performed.

3.1.9 Construction shall include excavation in all types of soils / rock inclusive of necessary dewatering as applicable.

3.1.10 The CONTRACTOR shall redo / repair all the existing facilities viz. roads, paving, drainage etc. which are damaged during transportation, construction and erection activities performed by him.

3.1.11 Rain water harvesting is mandatory for buildings. like control room, operator room, view room, change room & check room, security building, maintenance building, canteen, laboratory building etc.
4.0 Quality Assurance Plan

Contractor shall ensure the quality of civil works by engaging a third party supervision/inspection and provide test results to Owner/PMC for information. The Quality Assurance Plan is attached for reference as Annexure VIII and the contractor is obliged to follow it.

5.0 COMPLETENESS OF WORK/CONTRACT

5.1 The scope of work mentioned in the contract/NIT is not the comprehensive one, but gives total idea/outline of the scope of work; however contractor shall be responsible for completeness of the job for the purpose indicated elsewhere to make the system fully functional and operational.

5.2 In case there is any conflict in the specifications appearing in different contractual documents then the specification whichever is stringent shall be applicable without any technical or commercial implications.

5.3 The work furnished shall be complete in every respect with all mounting, fittings, fixtures and standard accessories etc. normally provided for such item/equipment and or needed/required for erection, completion and safe operation of the item/equipment/system as required by applicable codes though they may not have been specifically detailed in the respective specifications, unless included in the list of exclusions.

5.4 Any additional items and materials which are not specifically mentioned but are required to complete the system offered, in every respect in accordance with the technical specifications and required for safe operation and guaranteed performance shall also be deemed as included in the scope of work of this tender. Contractor shall not be eligible for any extra payment in respect of such mountings, fittings, fixtures, accessories etc. which are needed/required for safe operation of the item/ equipment/system, as required by applicable codes of the country though they may not have been explicitly spelt out in the NIT/Contract.
ANNEXURE - I

DESIGN PHILOSOPHY – ARCHITECTURAL
CONTENTS

1.0  GENERAL
1.1  SCOPE
1.2  UNITS OF MEASUREMENT
1.3  DEFINITION
1.4  CODES & STANDARDS

2.0  DESIGN PHILOSOPHY / CRITERIA - GENERAL
2.1  ARCHITECTURAL DESIGN
2.2  BUILDING REQUIREMENT
2.3  BUILDING SERVICES
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2.5  BUILDING ELEMENTS

3.0  BUILDING STRUCTURE

4.0  ARCHITECTURAL TRADES
4.1  EXTERNAL FINISHES
4.2  INTERNAL FINISHES
4.3  DOORS, WINDOWS & VENTILATORS
4.4  SANITARY FITTINGS & FIXTURES

5.0  MISCELLANEOUS
5.1  DRAWING
5.2  DESIGN
5.3  BUILDING REQUIREMENTS
1.0 GENERAL

1.1 SCOPE
The design philosophy defines the minimum design requirements and procedures for carrying out architectural design and engineering of buildings covered under this project. Relevant criteria shall be taken into consideration to achieve satisfactory and trouble free performance of the facilities.

1.2 UNITS OF MEASUREMENT
Units of measurement in design shall be in metric system.

1.3 DEFINITIONS

Owner              Talcher Fertilizers Limited (TFL)

PMC                To be selected

LSTK Contractor    Successful LSTK bidder of the tender (To be selected)

CCE                Chief Controller of Explosives

TAC                Tariff Advisory Committee

NFPA               National Fire Protection Association

IS                 Bureau of Indian Standards
1.4 CODES AND STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the applicable statutory regulations.

The main codes, standards and statutory regulations considered as minimum requirements are as follows. Latest revision of these shall be followed.

1.0 National Building Code of India
2.0 Factories Act of State
3.0 Local Municipality or any other Authority’s Bye-laws as applicable.
4.0 Bye-Laws applicable of Town & Country Planning Organization.
5.0 Code of practice for building bye-laws IS : 1256
6.0 TAC (Tariff Advisory Committee) Rules
7.0 Indian Electricity Rules
8.0 Bureau of Indian Standards

Note: The above list is suggestive and not exhaustive. Apart from the basic codes any other related codes shall also be followed wherever required.

1.4.1 Order of Precedence

In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows:

- Statutory Regulations
- Job Specifications
- Engineering Design Basis
- Standard Specifications
2.0 DESIGN PHILOSOPHY / CRITERIA – GENERAL

2.1 ARCHITECTURAL DESIGN

Architectural design of buildings / sheds shall be in accordance with this design basis and references as stated herein, to facilitate the intended functions. The various types of requirements to be considered are described further. In Plant Area no underground/ basement shall be provided in the building.

2.2 BUILDING REQUIREMENTS

2.2.1 Spatial Requirements

Spatial requirements inside a building / shed shall be decided based on activities to be performed in the building and consequent occupancy pattern, equipment layout etc. Spaces can be generally classified as functional spaces, circulation spaces, amenity spaces, utility spaces. They are elaborated further.

2.2.1.1 Functional Spaces

Functional areas of any building / shed is constituted by the main activity for which the building is required. Various spaces/rooms shall be judiciously sized and shall be integrated logically to generate the total building plan taking into account the following parameters :-

a) Activities, group of activities and consequent work-flow pattern.
b) Site conditions i.e., dimensions, contours etc.
c) Climatic conditions vis-à-vis orientation.
d) Safety regulations.
e) Lighting and ventilation.
f) Green building Concept for non plant buildings
g) Acoustics
h) Services
i) Security
j) Economy
k) Aesthetics
l) Specific requirements pertaining to particular buildings, if any
m) All other established architectural design parameters in practice.

The objective of spatial arrangement shall be to satisfy functional requirements and physical comfort and safety regulations as well as aesthetics which has significant role in creating a favourable working environment.

2.2.1.2 Circulation Spaces

Following spaces are classified as circulation spaces. These spaces shall be provided as per required building services, for integrating various types of spaces and as means of access / exit / escape.

a) Corridors & passages.
b) Staircases
c) Elevator
d) Entrance lobby / Foyer including Reception & waiting.
e) Gangway / walkways.
f) Equipment loading / unloading platforms
g) Emergency Exits

2.2.1.3 Amenity Spaces

Following spaces are classified as amenity spaces:

a) Toilet (Gents & Ladies).
b) Drinking Water Facility.
c) Locker & Change Room.
d) Rest room / Lunch Room.
e) First-Aid Room
Out of the above mentioned areas, a) Toilet, b) Drinking water, c) First Aid enclosures shall be mandatory requirement for all buildings / sheds under bidder’s scope. However, number of male, female & physically challenged person’s toilets will be decided during detailed engineering as per building by-laws.

Other facilities shall be provided as required.

2.2.1.4 Utility Spaces

Utility spaces are space requirements which materialize due to provision of services like air-conditioning, pressurization, fire fighting, electrical, telephone, LAN etc. Following are examples. These spaces shall be provided as per required building services.

i) Air-conditioning plant room.

ii) Air handling rooms.

iii) Pressurization blower plant room.

iv) Electrical distribution panels rooms.

v) Service ducts

vi) Firefighting equipment room.

vii) Telephone exchange equipment room.

viii) UPS room.

ix) Battery room.

2.2.1.5 Sizes of Spaces

Sizes of various type of spaces shall be decided based on occupancy / equipment / Panel / furniture layout, clearance, maintenance & safety requirements & ventilation requirements.

However, following are the limiting sizes / dimensions for various purposes, which shall be adhered to:

a) Minimum area of any habitable room = 9.5 m² with minimum dimension restricted to 2.5 m
b) Minimum height of any habitable room = 3 m which may be reduced to 2.75 m for air-conditioned areas. Due provision / clearance may be made for AC ducts above false ceiling if any. Headroom below beams should be min. 2.4 m.

c) Maximum height of habitable rooms = As stipulated by the local bye-laws

d) Scale of accommodation for industrial work spaces = @ 14 m³ per occupants. Minimum clear height of such workspaces shall be 3.6 m. Heights above 4.25 m shall not be taken into account.

2.2.2 Day Lighting and Ventilation

2.2.2.1 Day Lighting

Established level of illumination shall be maintained for all parts of the buildings by means of windows, ventilators, skylights, etc. Following references shall be adhered to in this regard.

a) National Building Code of India, Part-VIII, Section-1
b) IS:2440: IS 3646 (Part-II) : IS:7662 (Part-I)
c) State Factories Rules
d) Any other relevant rules / code etc.

Following architectural norms shall be adopted:
a) Direct solar illumination shall not be considered and only sky radiation shall be taken as contributing to illumination of the building.
b) Openings shall be provided with shading devices to avoid glare.

For the purpose of illumination, day lighting shall also be supplemented by artificial illumination.
2.2.2.2 Ventilation

A) Natural Ventilation
   Established level of ventilation in terms of air changes per hour shall be maintained for all spaces. Following references shall be adhered to for the purpose.

   a) National Building Code of India, Part-III, Section-1
   b) IS:3101 (industrial buildings), IS:3362 (residential buildings); IS:7662(Part-I)
   c) State Factories Rules
   d) Any other relevant rules / Codes etc.

   Natural ventilation shall also be supplemented by mechanical or electrical means of ventilation in all areas of habitation. Sufficient no of Glazed / Louvered windows / ventilators shall be provided and supplemented by exhaust fans.

B) Mechanical Ventilation
   In addition to natural ventilation, if required mechanical or electrical ventilation shall be provided depending on the type of building and its use. Other relevant design basis shall be referred for its requirement and applications.

2.2.3 Acoustics And Sound Insulation

Specified acceptable noise level and reverberation time shall be maintained inside a building / shed. Following references shall be referred to for the purpose.

   a) National Building Code of India.
   b) State Factory Rules.
   c) Limitations on decibel level stated elsewhere, if any, in the bid document
Required noise level in any space shall be maintained by means of
a) Segregating noise sources by buffer zones
b) Dampening of noise levels by damping devices
c) Providing Acoustic treatment with acoustic material (on walls, ceilings, floors, as required).

2.2.4 Safety Requirements
Safety from fire and like emergencies shall be taken into account in building / shed design. Buildings / sheds meant for human occupancy shall be provided with exits sufficient to permit safe escape of occupants in case of an emergency. The exits shall be in terms of doorway, corridors, and passage ways to internal / external staircase or to areas having access to the outside. Following references shall be adhered to this regard. Max distance to an exit from any point in a building shall not exceed 30 m. Control Room building shall be provided with emergency exit on the other side of entrance.

A minimum of two staircases and two exits per floor shall be provided in each building. Width of passage / corridor shall not be less than 1500 mm. Following references shall be referred to for the purpose design of Control Room building.

a) National Building Code of India, Part-IV
b) State Factories Rules.
c) Any other relevant rules / codes.

2.2.5 Site Planning & Landscaping
Site planning of building shall take into account aspects like inter-relationship of the buildings with the whole system, movement pattern, traffic and road net-work, safety regulations, service network, fire safety, climatic and environmental aspects.
Main and service / maintenance entrances of buildings shall be provided with vehicular access. All exit points shall also be provided with footpath / vehicular access. Truck movement space in accordance with traffic pattern shall be provided for the building as per the location of hoisting bay / loading, unloading platform. Road network and open space around the buildings shall be designed considering movement and functioning of fire tenders and cranes, etc.

Landscaping to be done for areas around control room and technical lab building within bidder’s battery area excluding hard paved area. Such treatment shall generally consist of lawns, road side plantation and beautification of building entrance areas. Standard landscape elements such as earth contours, paving, flower beds, hedges, shrubs, ground cover and ornamental trees shall be incorporated in landscape treatment. Necessary water supply / sprinklers shall also be provided. Wherever required, Grass for landscaping shall be “Selection Grass”.

2.3 BUILDING SERVICES

Following services shall be provided for all building / sheds as essential services.

2.3.1 Water supply, Distribution and Drainage, Sanitary Services.

The service is essential for all habitable buildings / sheds. All buildings with human occupancy shall have toilet and drinking water facility and accordingly water supply, distribution and drainage, sanitary services as per following references.

a) National Building Code of India, Part-IX, Section 1 & 2
b) State Factories Rules.

Drinking water provisions, including one number water cooler per area (of approx 20 m x 20 m) shall be provided within an enclosure separated from the toilets.
Space for janitor shall be provided in the toilets. All service pipes showing on the external wall shall be suitably concealed or shall be provided within a shaft.

Each building shall be equipped with approved PVC overhead water tanks of capacity not less than 2000 litres.

2.3.2 **Electrical Services**

This service shall be provided as essential service for all building / sheds. Electrical services for buildings shall consist of electrical supply and distributions, electrical lighting installations, telephone network, fans, exhaust fans, lighting protection system etc. including all accessories, cabling etc. including emergency power supply, all as per requirement. All electrical switches / sockets shall be of modular type as per the approved makes given separately.

**Air conditioning and Heating**

Areas of control room, spaces housing equipment / machinery / panels etc. which required conditioned environment and certain specified areas like offices, specific office accommodation shall be suitably air-conditioned by window / split / package / centrally air-conditioned type units, as per requirement with respect to other relevant Design Basis.

Accordingly, AC Plant / AHU etc. of the required capacity, whenever required, shall be provided and housed, suitably.

2.4 **AESTHETICS**

Apart from the fulfillment of functional & safety requirement, aesthetic requirement of the buildings / sheds shall be taken care of in the design. As specific guidelines for achieving required aesthetics are difficult to establish, following guidelines shall be followed:
a) Preliminary Drawings including perspective views indicating architectural
treatment minimum three different alternative proposals shall be submitted for
Owner’s approval.

b) Following elements shall be considered as contributory elements to aesthetics
and their design etc. shall be subjected to the Owner’s approval. Any change /
modifications sought for aesthetics improvements with regards to these
elements shall be carried out. Any incidental elements like brickwork, RCC work
etc. required for such changes / modifications shall also be added.
   i)   Building / shed shape and features
   ii)  Canopies, overhangs & shading devices
   iii) Gutters
   iv)  Entrance / exit steps, door
   v)   Window / Ventilator composition
   vi)  External wall location with respect to columns
   vii) Colour scheme, grooves in plaster
   viii) Spatial arrangement
   ix)  Aesthetic of the buildings should match with the surrounding existing
        facilities at the site.

2.5   BUILDING ELEMENTS

2.5.1 Plinth protection

All the buildings & sheds shall be provided with minimum 1000 mm wide plinth
protection around the building / shed. Level wise, it shall be 100 mm high above top
of approach road level. In order to avoid accumulation of water outside the
buildings, requirement of surface drains shall be examined on case to case basis
for individual building and provided if necessary.

2.5.2 Finished Floor Level (Plinth FFL)

In general, Plinth FFL of the buildings, sheds shall be determined with respect to
top of approach road or pavement. Unless noted otherwise on the reference
drawings, following schedule shall be adhered to for FFL of various buildings &
sheds.
<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Sub Station Building</td>
<td></td>
</tr>
<tr>
<td>&gt; Cable cellar floor</td>
<td>Top level of approach road + 450 mm/or as specified in Electrical section of NIT</td>
</tr>
<tr>
<td>&gt; Transformer bay with pebbles</td>
<td>Top level of approach road + 150 mm/or as specified in Electrical section of NIT</td>
</tr>
<tr>
<td>&gt; Single storey substation with trenches</td>
<td>F.G.L. (+) approx. 1000 mm high from top of road/or as specified in Electrical section of NIT</td>
</tr>
<tr>
<td>b) Transformer bay</td>
<td>Top level of approach road + 150 mm/or as specified in Electrical section of NIT</td>
</tr>
<tr>
<td>c) Vehicle, scooter, cycle shed including fire tender bays, repair shop</td>
<td>Top level of approach road + 300 mm</td>
</tr>
<tr>
<td>d) False floor areas (Control Room)</td>
<td>As specified in the Instrumentation section of NIT</td>
</tr>
<tr>
<td>e) Loading, Unloading bays, platforms</td>
<td>Top level of approach road + 1100 mm</td>
</tr>
<tr>
<td>f) Electrical rooms</td>
<td>As specified in the Electrical section of NIT</td>
</tr>
<tr>
<td>g) Other Buildings / Shed (Process Operator’s Cabin)</td>
<td>Top level of approach road + 450 mm from surrounding ground level.</td>
</tr>
</tbody>
</table>

**Notes:**

a) In case of approaches with different top levels, the highest top level of approach road/pavement shall be considered.

b) FFL shall be same throughout in a building/shed. Split levels any be considered in exceptional cases due to ground terrain etc.

c) FFL of external loading/unloading bays/platforms, toilet, pantry, kitchen shall be 6 – 12 mm lower than that of the building/shed’s FFL to check ingress/spillage of rainwater.

d) FFL of Warehouses, stores may be kept lower than loading/unloading bays/platforms where forklifts etc. are used for internal movement of items. Adequate arrangement for negotiating the level difference shall be provided in that case.

e) Where applicable, existing levels of building/sheds shall be followed.
2.5.3 Steps / Ramps

Steps / ramps shall be provided for access to the buildings / sheds for pedestrian /vehicular movement, equipment entry, etc. Minimum 1500 mm wide platform shall be provided in between entrance door and steps / ramps. Following dimensions of the steps / ramps shall be adhered to:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Tread</td>
<td>300 mm minimum</td>
</tr>
<tr>
<td>b) Riser</td>
<td>175 mm maximum</td>
</tr>
<tr>
<td>c) Slope of ram</td>
<td>Not steeper than 1:10 slope</td>
</tr>
<tr>
<td>d) Ratio of tread &amp; riser</td>
<td>2 Riser + Tread = 600 to 650 mm</td>
</tr>
<tr>
<td>e) Landing width</td>
<td>1500 mm minimum</td>
</tr>
<tr>
<td>f) Flight width</td>
<td>1500 mm minimum</td>
</tr>
</tbody>
</table>

Edge of treads shall be provided with friction grip strips

2.5.4 Wall

Following schedule shall be adhered to for wall material and thickness

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.  Blast Proof Wall</td>
<td>Min 230 mm thk. RCC wall</td>
</tr>
<tr>
<td>2.  Rain water duct / shaft</td>
<td>Min. 230 mm thk. hollow/ solid concrete block work</td>
</tr>
<tr>
<td>3.  External walls</td>
<td>230 mm thk. hollow/ solid concrete block work</td>
</tr>
<tr>
<td>4.  Fire wall (Around transformers)</td>
<td>240 thk RCC or 355 mm (including plastering) thick hollow/ solid concrete block work wall / OR as per Electrical requirements. (IER/TAC)</td>
</tr>
<tr>
<td>5.  Internal partition wall</td>
<td>230 / 115 mm thk. hollow/ solid concrete block work wall depending on the overall length and height of the wall (refer notes below)</td>
</tr>
</tbody>
</table>
a) 115 mm thick partition walls shall be provided with RCC transoms and mullions for suitability.

b) Wherever conduits or pipes are required to be concealed within partition wall, the local wall thickness shall be increased suitably.

2.5.5 Doors

Doors shall be provided for access, security and safety to all rooms, functional areas in a building. Air tight door shall be provided in pressurized area and in gaseous protection area. Emergency door shall be opened outwards. Sizes of the doors shall be determined on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Category</th>
<th>Size Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment, Panel area</td>
<td>Maximum size of equipment including packing</td>
</tr>
<tr>
<td>Other areas</td>
<td>Volume of movement through door</td>
</tr>
<tr>
<td>Minimum door size at entrance</td>
<td>1500 mm x 2500 mm (masonry opening size)</td>
</tr>
<tr>
<td>W.C. bath Cubicle door</td>
<td>800 mm x 2100 mm (masonry opening size)</td>
</tr>
<tr>
<td>Minimum size of other doors</td>
<td>1000 mm x 2100 mm (masonry opening size)</td>
</tr>
</tbody>
</table>

Notes:

a) Entrance doors shall be provided covering full width of the entrance lobby. In that case the door shall be of composite type consisting of openable shutters & fixed panels. Entrance lobby shall be provided with elaborate canopy.

b) Rolling shutters min 2500 mm wide shall be provided for equipment entry for Switchgear room, Electrical room, A.C. Plant room etc. and also wherever size of opening exceeds 2500 mm x 2500 mm.

c) Mechanically operated rolling shutters shall be provided for main equipment entry opening, and also where opening size exceeds 8 m².

d) Fireproof door shall be with two hours fire rating as per statutory requirements.

e) Blast resistant Control room entry door shall be provided with blast resistant baffle wall in front of entry door and shall have 45 degree / 90 degree overlap on both sides as per relevant standard/codes.
2.5.6 Windows / Ventilators

Windows / ventilators shall be provided in all areas for natural lighting, ventilation, and visibility of working level. For the purpose of ventilation, total openable area of the windows / ventilators shall be as per Factories Act subject to a minimum of 15% of the floor area to be ventilated. However, for control room and in office areas, etc. where visibility from inside is also important, increased window area (as per discussion with Owner/PMC) shall be provided. Areas accommodating panels / equipment shall be normally provided with ventilators at high level for uniformity distributed lighting.

Notes:

a) Requirements of window / ventilation area as stipulated above is for maximum room height of 4000 mm. For heights more than 4000 mm, additional window / ventilator shall be provided in the same manner at every work area / platforms at all levels.

b) Wherever due to limitation of external wall area or other reasons, stipulated area of window / ventilator cannot be provided, suitable mechanical / electrical system shall be employed.

c) Fly mesh shutters shall be provided for windows / ventilators in Kitchen, Pantry, Dining hall etc.

d) Ventilator shall be able to serve as smoke vents in the event of fire.

e) For structures like workshop / warehouse / compressor shed with pre-coated or G.I. roof sheeting, suitable monitor may be added to provide proper ventilation.

f) Fireproof windows shall be provided as per TAC, electrical, process, etc. statutory requirements.

g) External windows shall have P.C.C. (1:3:6) sills, 100 thk.

h) All glasses in windows & doors shall be toughened glass. Outside glasses shall be tinted toughened.

2.5.7 Canopy / Overhang

RCC Canopy / Overhangs shall be provided at all entrances for rain / sun protection, accentuation of the entrances, and pedestrian movement as per the following schedule:
a) For all offices, control rooms, composite buildings / sheds accommodating offices, canopy shall be provided at all entrances. Size of the canopy shall be decided based on vehicle parking & pedestrian movement in addition to aesthetics of the building / shed. Bottom of canopy shall be minimum 2800 from top of drive way.

b) Overhangs shall be provided over all exits. Size of the overhang shall be decided on the aesthetics of the building / shed subjected to minimum of 1000 mm.

Blast proof Control rooms shall not have any projections on outer face of its walls except with false treatment for aesthetics of the building.

2.5.8 Shading Devices
RCC Shading devices shall be provided over all windows, openable ventilators for rain & sun protection. These devices shall be in form of horizontal projections, vertical projected fins or combination of both as per building façade treatment. Minimum projection shall be 600 mm.

2.5.9 Parapet
Parapets shall be of RCC for all buildings with minimum 500 mm high for non-approachable roof and 1100 mm high for approachable roof.

2.5.10 Roof Gutter
Gutter with rainwater pipes shall be provided for all the buildings / sheds for roof water drainage. Sizing of the gutter shall be based on areas to be drained and number of outlets. Gutters shall be of RCC or sheet metal depending on type of structure.

2.5.11 Rain Water Pipes Spouts
PVC rain water pipes shall be provided for roof water drainage. Number of rain water pipes shall be decided on the basis of roof area, slope and rainfall intensity as
per NBC-IX, Section-2. Rain water pipes shall be concealed as far as possible. RCC or GI spouts may be used for drainage of chajja / small canopies of ground floor. Dia of rain water pipe shall be 150 mm minimum.

2.5.12 Entrance Lobby

Entrance lobby shall be provided as a common entrance for all buildings / sheds accommodating separate functional spaces integrated together. Individual entries to such functional spaces shall be from this lobby by means of passages / corridors. Apart from common entry lobby, separate independent entries to these functional spaces shall also be provided if functionally required. Size of the entrance lobby shall be decided on the basis of volume of movement. Air lock lobby shall be provided for all entries with centrally air-conditioned spaces, and pressurized.

2.5.13 Passage / corridors

Passage / corridors shall be provided to integrate various spaces. Width of the passage / corridors shall be as per statutory requirement, subject to a minimum width of 1500 mm.

2.5.14 Service Entry

Separate service entry shall be provided for service areas such as kitchen, air-condition / pressurization plant room, electrical rooms. A common service entry may be provided depending on spatial arrangement.

2.5.15 Emergency Exits

Emergency exits shall be provided for all the building / sheds as per statutory requirements. Emergency exits for individual function spaces such as console area, cable cellar, and switchgear hall shall also be provided. Emergency exits shall be located in such a manner that escape route is unobstructed & without passing through any other function areas. Corridors / staircases shall be provided as escape route.
2.5.16 Staircases

Staircases shall be provided in multi floor buildings for vertical circulation & emergency exits. Number of staircases shall be based on building / shed sizes, emergency exit requirements, and travel distances to exit points as per statutory regulations. More than 500 sq m ground covered area shall have at least two stairs in line with NBC-Part-IV. Emergency exit requirements shall be as per safety distance requirement. At least one staircase shall be provided for access to the flat roof tops for maintenance. Following dimensions for staircases shall be adhered to.

<table>
<thead>
<tr>
<th></th>
<th>Stairs width</th>
<th></th>
<th>1500 mm minimum, (1000 mm minimum for emergency exit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>Staircase width</td>
<td>:</td>
<td>1500 mm minimum, (1000 mm minimum for emergency exit)</td>
</tr>
<tr>
<td>b)</td>
<td>Tread</td>
<td>:</td>
<td>300 mm minimum</td>
</tr>
<tr>
<td>c)</td>
<td>Riser</td>
<td>:</td>
<td>150 mm maximum</td>
</tr>
<tr>
<td>d)</td>
<td>Ratio of tread &amp; riser</td>
<td>:</td>
<td>2 Riser + Tread = 600 to 650 mm</td>
</tr>
</tbody>
</table>

2.5.17 Railings

Railings shall be provided in roofs, stairs and in all unprotected openings in slabs as a safety device. Railings in high level loading / unloading bay of substations shall be of removable type. Parapets shall be given precedence over railings in roofs. All Hand Railings (in buildings only) shall be of SS-304 grade of design as per direction / approved by owner.

2.5.18 Toilets

Toilets shall be provided for all habitable buildings / sheds. Gents & ladies Toilet, drinking water enclosure & janitor space, all shall be provided as required. The fittings / fixtures provided for bath / toilet shall be of luxury / colored type.

2.5.19 Partitions

If required partitions shall be provided for flexible space arrangement in office spaces, Control room etc. The partitions shall be modular, dismantleable type of Godrej or approved equivalent make.
2.5.20 False Ceiling
False ceilings shall be provided for following purposes:-

a) To reduce room volume and hide ducting etc. for air conditioned spaces.
b) To maintain acoustic level inside any space.
c) To reduce habitable room, corridor, lobby, toilet heights located in high ceiling building / shed to a reasonable and satisfactory height of minimum 3000 mm.
d) In fire rated areas where walls and doors are required to be fire rated, false ceiling shall also have complementing fire rating. It is appreciated that false ceiling have limitations in their fire performance due to openings in them for lighting and air conditioning. Therefore alternative systems to prevent puncturing the ceiling must be employed.

2.5.21 Under deck Insulation
Under deck insulation below RCC roof and over false ceiling (both locations) shall be provided for air-conditioned office / space.

2.5.22 False / Cavity flooring
False / cavity flooring, consisting of cement filled flooring sheets with antistatic lamination on the top, of approved make / as directed by Engineer in charge, shall be provided to accommodate under floor cabling in all areas. Extent of false / cavity flooring shall be as per functional requirements.
False flooring shall be fire rated to the level of fire rating of the walls, doors and suspended ceiling in the compartment.
Cavity flooring for Control Room buildings, specifications given in Instrumentation section is to be followed.

2.5.23 Waterproofing on roofs
Water proofing (for all open terraces) of all buildings shall be done by water proofing PU coating with treatment also, of approved Brand and make.
Wherever there is human/machine movement anticipated, it is preferable to use Brickbat waterproofing over roof.
2.5.24 Dash fasteners, if used, shall be of approved make or as directed.

3.0 BUILDING STRUCTURE

The layout of the buildings shall be finalized within 3 months after the effective date of contract.

The design considerations, type of buildings and specifications of various buildings shall be as generally defined under this clause, unless stated otherwise as per plant Requirements:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Building Description</th>
<th>Design Consideration</th>
<th>Type of Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Operators &amp; Maintenance/Control Room building</td>
<td>Rack layout, occupancy</td>
<td>RCC blast resistance structure as per specifications/ relevant standard/codal requirements including Hollow /Solid Concrete Block work infill walls</td>
</tr>
<tr>
<td>2</td>
<td>Sub station</td>
<td>Equipment layout, occupancy</td>
<td>RCC frame, hollow/solid concrete block work/ masonry infill walls</td>
</tr>
<tr>
<td>3</td>
<td>Technological structures</td>
<td>Equipment layout, occupancy</td>
<td>Structural steel Framed Structure</td>
</tr>
</tbody>
</table>

4.0 ARCHITECTURAL TRADES (To be finalized in consultation of OWNER/PMC)

All the buildings shall be provided with Architectural finishes such as floor finishes, plastering & painting on walls & ceilings, doors / windows / ventilators, roof treatment, plinth protection, etc. pertaining to approved make/brand and best quality for industrial usage.
4.1 EXTERNAL FINISHES  (To be finalized in consultation of OWNER/PMC)

4.1.1 External Wall
   a) Substation Room, Operator & Maintenance building - Weather proof Exterior Acrylic Emulsion paint of approved brand, quality, make and shade as per direction of Owner.
   b) Control Room – Sand Stone Cladding

4.2 INTERNAL FINISHES  (To be finalized in consultation of OWNER/PMC)

4.2.1 Floor Finishes
   a) Office area, & Sub station
      Vitrified tiles in glazed or matt finish / Marbo-granite tiles
   b) Toilet, Drinking Water area
      Granite flooring
   c) Circulation area (Corridor / Passage etc. except Entrance Lobby) of Substation - Kota stone flooring
   d) Circulation area (Corridor / Passage etc. except Entrance Lobby) of Control room –Complete flooring (except False flooring area) to be Granite or Vitrified tiles or combination of both as per direction of Owner. Selection of quality, shade etc. for Granite / Vitrified tiles shall be based on good engineering practices and done as per Owner’s direction / approval.
   e) Switch Gear, Cable Cellar, A.C. Plant Room, storage area
      Switch gear Room for substation will have Kota Stone Flooring. Rest of the buildings wil has heavy Duty Decorative Ceramic Tiles. / Hardcrete Floor, as directed by E.I.C
   f) Battery Room
      Acid resistant epoxy coating over IPS-flooring & 2100 high dado.
   g) Entrance lobby, corridor lobby of main building- granite flooring

Note:
Skirting shall be provided in all areas, which shall be of same material as that of flooring. Glass strip panel shall be provided in cement concrete flooring.
4.2.2 Internal Wall Finishes for applicable buildings/structures

a) Entrance lobby, Corridor lobby:
   Granite stone cladding and plastic emulsion paint.

b) Office areas of Buildings:
   Cement plaster, POP punning & plastic emulsion paint

c) Circulation areas (Corridor / Passage etc. excepting Entrance lobby) of Buildings
   Cement plaster, POP punning & plastic emulsion paint

d) Rack Room, Office Rooms, Operators Room
   Cement plaster, POP punning & plastic emulsion paint

e) Switchgear Room / Electrical Room
   Cement plaster & Plastic Emulsion paint (Switchgear Room)

f) Battery Room
   Acid resistant epoxy coating over cement plaster up to 2100 height. Plastic emulsion paint above 2100 height.

g) Toilet, Drinking water area
   Granite stone cladding / Marble / Ceramic tiles as directed by E.I.C

h) Inside surface of Prilling tower:
   Suitable Epoxy coating (like IPN epoxy phenolic coating) of approved Brand, Make and shade as per direction of owner.

4.2.3 Internal Ceiling Finishes

a) Toilet Electric Operator, Rack room, MCC panel room, UPS
   All false ceiling shall be either Gypsum board false ceiling or Armstrong false ceiling or combination of both as per direction of owner. Further, false ceiling shall also have fire rating complying with safety requirements. Also refer Instrumentation and Electrical specifications.

b) Other areas which do not have false ceiling
   Cement plaster & white / color wash, plastic emulsion paint etc., as in the case of wall finish.
4.3 DOORS, WINDOWS & VENTILATORS

4.3.1 DOORS

All frame works shall be in Sal/chap wood in size 125 x 65 mm.

a) All doors in Toilet / WC / Bath
   35 mm flush door laminated with 01mm laminate from both sides.

b) All doors of Electrical Room, A.C. Plant Room, Battery Room
   Pressed steel frame with pressed steel shutter (or as specified in Electrical
   section).

c) Inside Control Room
   Fire check door with 2 hours rating as required in perfect partition wall
   separating various fire zones (or as specified in Instrumentation section)

d) All other doors of Control Room / Satellite Rack Room / Sub station
   Glazed, powder coated Aluminum door with decorative etching (or as specified
   in Instrumentation section).

4.3.2 WINDOWS & VENTILATORS

a) Windows / ventilators
   Glazed, powder coated aluminum window / ventilator.

4.4 SANITARY FITTINGS (Make: Jaquar/Cera/Hindware/Perryware or equivalent)

a) Water Closet for Control Room
   Wall hung type colored European designer type WC.

b) Water Closet for Sub Station
   Pedestal type white European designer type W.

c) Water Closet (Indian)
   Orissa type (Indian) pan white WC.

d) Wash basins for Control Room.
   Round wash basin white / colored housed in granite counter with electronic
   sensors for water control, approved quality mirror. Front portion below the
   counter shall be covered with shutters of laminated boards.

e) Wash basins for Sub Station / Satellite Control Room.
   Wall hung wash basin with pedestal.
f) Plumbing fixtures.
   Stainless steel bib cock, stop cock etc. fittings.

g) Urinals of approved Brand, Make, size, shape and color shall be provided in Control Room with Electronic sensors for water control, along with Glass partitions of approved brand, make size and shape etc.

5.0 MISCELLANEOUS

5.1 ARCHITECHTURAL DRAWING

5.1.1 Plant datum shall always be 100.00 meters and its correspondence to the reduced level with respect to the mean sea level shall be indicated in the “NOTES” (Unless it is already established).

5.1.2 Location co-ordinates shall be indicated on grids.

5.1.3 Reference drawings, notes, holds list, schedule of finishes including painting, door and window schedules, area statement, notes on plastering, key plan, were necessary, shall appear in the first drawing sheet of a building. Subsequent sheets can cover them by a reference to the first sheet.

5.1.4 Elevations shall show siography to highlight features, human figures for scale, automobiles for headroom, trees and foliage for appearance.

5.1.5 False ceiling area shall be shown by hatching suitably.

5.1.6 False flooring area shall be shown by hatching suitably.

5.1.7 Air-conditioned rooms shall be identified suitably.

5.2 DESIGN

5.2.1 Entrances shall be elaborate and well sheltered to accommodate pedestrians and vehicles.

5.2.2 Provision for future extension, vertical and horizontal shall reflect in the work.
5.2.3 Toilet, kitchen and pantry floors with waterproofing and sloped for drainage. The finished floor level shall be 25 mm below the general finished floor level. Tile drops shall be indicated were required. For example from general floor to toilet floor, toilet floor to WC / Shower floor, general floor to pantry, general floor to entrance platforms and so on.

5.2.4 Plumbing works, external drainage, schematic, flow, shall be indicated.

5.2.5 Water tanks, AC plant, cooling tower, Chiller units etc., where required, shall be located on building roof as far as possible and it shall be positioned and supported to transfer its load on to beams and columns and not to the slab. Such facilities should not be visible from outside. Suitable side cladding shall be provided for this purpose.

5.2.6 Access to all roofs via steel ladder. In case of accessible roofs at least one staircase shall go up to the roof.

5.2.7 Plinth beams level shall clear trenches if any.

5.2.8 Vertical ducts for running services must be examined.

5.2.9 Ventilator arrangement shall be provided unless situations strongly prevent or make it unnecessary. In addition to ventilation requirements, ventilators shall have the capacity to vent smoke in the event of fire.

5.2.10 Layout shall take into account the type of air-conditioning and built-in provisions shall be made to accommodate the equipment.

5.2.11 Walls on steel beams shall be constructed after wall below and up to the steel beam is constructed. This shall appear in the ‘Notes’ if applicable.

5.2.12 Gaps in floor cut outs shall be sealed with fireproof material for fire safety.
5.2.13 Openings in wall / cladding for pipes and cables from pipe rack / trays shall be made water tight primarily by means of design features.

5.3 BUILDING REQUIREMENTS

5.3.1 All free edges of chajjas and slab projections shall have drip mould in plaster 50 mm wide and 20 mm drop, unless the need is resolved in some other manner.

5.3.2 Floor slab in WC areas shall be sunk by 500 mm and toilet, pantry, kitchen floor slabs shall be sunk by 200 mm at all levels (including terrace, where future extension is envisaged).

5.3.3 All partition walls within toilet kitchen areas shall be 115 mm thick and 2200 mm high.

5.3.4 All supporting framework members of partition walls within false ceiling areas shall go up to roof level, partitions shall go up to false ceiling level except where there are fire compartment wall where it shall be from floor to ceiling.

5.3.5 All windows and ventilators opening periphery shall have granite embedded in cement mortar 1:3.

5.3.6 Preferably all cut out in slab shall be provided with 200 mm high kerb.

5.3.7 Groove in plaster, 20 wide x 10 deep shall be provided aesthetically to break extensive areas of plaster.

5.3.8 Flooring shall be done in panels, preferably in 3000X3000 mm size with expansion joints provided at 25000 mm c/c.

5.3.9 Flooring contraction joint shall be provided as per design.

5.3.10 Parapet walls shall be at least 1100 mm high.

5.3.11 Roofs of RCC buildings should have mild slope towards rain water gutters.

5.3.12 All Instrument / Electrical cables at the junction of the building (outside) shall be covered with pre-cast RCC slab. Sleeve pipes should be provided for the cable in the masonry wall including its sealing.

5.3.13 All new buildings (except for Blast proof Control Room) shall be designed for vertical extension of one additional storey over and above bidder’s plan to accommodate requirement in future.
ANNEXURE II

DESIGN PHILOSOPHY – GENERAL CIVIL & DESIGN BASIS
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1.0 GENERAL

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1.2 UNITS OF MEASUREMENT
1.3 DEFINITIONS
1.4 CODES AND STANDARDS

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2.2 ROADS
2.3 CONCRETE PAVING (WITHIN PLANT AREAS)
2.4 SURFACE TREATMENT
2.5 STORM WATER DRAINAGE
2.6 WATER SUPPLY
2.7 SANITARY SEwers
2.8 CONTAMINATED RAIN WATER SEwers
2.9 OTHER PROCESS DRAINS
2.10 STORAGE TANK FOUNDATION AND DYKE WALLS
2.11 BARRICADE
2.12 TRENCHES
2.13 HARD SURFACES

3.1 REMOVAL / REROUTING OF CONSTRUCTIONS
1.0 GENERAL

1.1 SCOPE

This engineering design basis defines the design criteria that shall form the basis for carrying out design and engineering of items under general civil, viz. roads, paving, drainage, etc.

1.2 UNITS OF MEASUREMENTS

Units of measurement in design shall be metric system.

1.3 DEFINITIONS

Owner            Talcher Fertilizers Limited (TFL)
Consultant       To be selected
LSTK Contractor   Successful bidder of the tender
CCE              Chief Controller of Explosives
TAC              Tariff Advisory Committee
NFPA             National Fire Protection Association
IS                Indian Standards

1.4 CODES AND STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country.

1.4.1 The main codes, standards and statutory regulations considered as minimum requirements are as follows. Latest revision of these shall be followed.
IS: 456  Code of practice for plain and reinforced concrete
IS: 800  Code of practice for general construction in steel
IS: 875  Code of practice for design loads (Other than earthquake for buildings & Structures
IS: 1172 Code of basic requirements for water supply, drainage & sanitation
IS: 1742 Code of practice for building drainage
IS: 1905 Code of practice for structural use of unreinforced masonry
IS: 2065 Code of practice for water supply in buildings
IS: 2212 Code of practice for brick work
IS: 8835 Guidelines for design of surface drains.
IRC: 6  Code of practice for road bridges, Section-II Loads and stresses
IRC: 19 Standard Specifications and Code of Practice for Water Bound Macadam
IRC: 37 Design of flexible pavements
IRC: 58 Design of rigid pavements
Factory Rules for State

Note: The above list is suggestive and not exhaustive. Apart from these basic codes, any other related codes shall be followed wherever required.

1.4.2 In case of any conflict / deviations amongst various documents, the order of precedence shall as follows –

- Statutory regulations
- Job specifications
- Engineering design basis
- Standard specification
2.0 DESIGN CRITERIA – GENERAL

2.1 SITE GRADING

2.1.1 The work area shall be cleared and stripped completely of all bushes, roots, trees, Shrubs and other vegetation, organic matter and other objectionable materials. All these should be completely uprooted and removed, and not merely scraped at the surface.

2.1.2 The grading of the area, if required, shall be done by cutting and filling with the following:

   a. Cutting Area : Thoroughly rolled and compacted.
   b. Filling Area  : Compacted in layers not exceeding 20cm to Achieve minimum 95% of maximum dry density.

2.1.3 Site grading philosophy shall be based on following:

FFL of the adjacent paved area is ........m above Mean Sea Level (To be decided later).
However, levels like Finished Ground Levels (FGL) and Highest Point of Paving (HPP) shall be finalised by the CONTRACTOR, in consultation with OWNER / PMC, based on contour survey of the Unit, levels of adjacent units and levels of adjacent Roads.

2.1.4 Slope in Graded Areas

<table>
<thead>
<tr>
<th>Description</th>
<th>Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. General Site Grading</td>
<td>1 in 500 to 1 in 1000</td>
</tr>
<tr>
<td>b. Micro grading, after completion of major construction (for road corridors)</td>
<td>1 in 200</td>
</tr>
<tr>
<td>c. Tanks Farms</td>
<td>1 in 200 to 1 in 300</td>
</tr>
</tbody>
</table>
2.2 ROADS

Contractor shall design cross section of roads, including roads for crane access, as per IRC 37. However, the minimum section to be adopted shall be as given in clause 2.2.7 Ruling gradient shall not exceed 1 in 20. If existing roads are to be used for erection purposes, the same should be strengthened to cater for erection loads. It should be ensured that use of existing roads does not hinder normal activities in existing plants.

2.2.1 ROAD WIDTH

<table>
<thead>
<tr>
<th>Category</th>
<th>Width*</th>
<th>Carriageway Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Road around unit and its Primary access</td>
<td>12.5 m</td>
<td>10.5 m (three lane road or width to suit crane type)</td>
</tr>
<tr>
<td>ii. Roads for high lifts crane 2.0 m+ c.w. width</td>
<td>3 m + outer width of crawlers of required Capacity crane.</td>
<td></td>
</tr>
<tr>
<td>iii. Plant approach road 9.0 m</td>
<td>7.0 m (two lane)</td>
<td></td>
</tr>
<tr>
<td>iv. Roads around tank farm 7.5 m</td>
<td>5.5 m</td>
<td></td>
</tr>
<tr>
<td>v. Patrolling roads (along boundary wall) 6.0 m</td>
<td>4.0 m</td>
<td></td>
</tr>
<tr>
<td>vi. Access to building 5.5 m</td>
<td>3.5 m</td>
<td></td>
</tr>
<tr>
<td>vii. Foot path 1.0 m</td>
<td>.......</td>
<td></td>
</tr>
</tbody>
</table>

* Width of the road to be finalised as per site condition/Plot plan requirements in consultation with client / PMC.

2.2.2 Camber 1 in 50

2.2.3 Radius of curve: 12 m for 8 m wide carriage way roads, 8 m for 5.5 m wide Carriage way width & 15 m for roads of higher carriageway width.
2.2.4 **Pavement Type:** Concrete pavement at all roads to be used for crane movement (Requirement of crane movement route and its specification to be finalised in consultation with client /PMC)

2.2.5 **Extents:** As per Plot Plan / Equipment Layout drawing / scope drawing.

2.2.6 **Clearance:** Minimum 8.0 m to underside of pipe racks or as per Design Philosophy (Piping).

2.2.7 **Minimum Cross Section**

i. **Sub base:** The sub base shall be 300 mm layer of crushed / broken size stones on well compacted earth or approved fill.

ii. **Base course:** The base course shall be 225 mm stone size thick water bound macadam consisting of 3 layers of 75 mm each or Wet mix macadam roads.

iii. **Bituminous wearing course / RCC:** The wearing course shall be 75 mm thick for roads with crane duty and 50 mm thick for roads without crane duty. However, roads for crane movement, concrete pavements shall be provided.

2.2.8 **Crossings**

<table>
<thead>
<tr>
<th>Crossing Type</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Pipe Ways under roads &amp; rails</td>
<td>RCC Box Culverts</td>
</tr>
<tr>
<td>b. Storm Water Culverts Under road / rail.</td>
<td>RCC Box Culverts</td>
</tr>
<tr>
<td>c. Electric / Instruments Cable</td>
<td>RCC duct bank with PVC Pipe Class – 1 (IS 4985)</td>
</tr>
</tbody>
</table>

2.2.9 **Finished Road Top Levels above FGL**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>When box culverts for pipe ways are provided</td>
<td>1.05 m (minimum)</td>
</tr>
<tr>
<td>Ways are provided</td>
<td>1.6 m at box culvert location with a slope from 1.05 m to 1.6 m above FGL</td>
</tr>
</tbody>
</table>
2.3 CONCRETE PAVING (WITHIN PLANT AREAS)

2.3.1 General

RCC paving to be done for entire battery limit and extend up to the adjacent roads around the unit. The contractor’s scope is limited to units’ peripheral roads. Heavy duty paving shall be designed for heavy vehicular traffic movement as per IRC Loading.

Concrete paving shall be laid in cast-in-situ panels of 3.0 meter X 3.0 meter size, with expansion joints spaced approximately 15.0 m c/c, each panel being cast in a single pour.

Hard stands should be designed and provided by contractor, based on required crane capacity, here called for by Owner, the same shall be demolished after erection, and surface made good.

Provision of trenches, drains, sealing of trench covers, inserts, thickening for pipe / equipment supports etc. shall be made while construction pavements, as detailed in drawings.

Acid / alkali / chemical resistant coating as required shall be applied in areas where such corrosive materials are likely to come in contact with concrete.

Suitable drainage arrangements will be provided within curbed areas around pumps, for drainage leaks. Similarly, suitable drainage arrangement shall be provided at streaming points also.
2.3.2 Joints

Expansion joint of 20 mm shall consist of 20 thick impregnated fibre boards. Filled at top with joint sealing compound 20 x 25.

Equipment / column pedestals will be separated from paving with 20 thick sand fill and Sealing compound 20 x 25.

Contraction joints will be sealed by sealing compound 10 x 40.

2.3.3 Slope: 1 in 100 (minimum)

2.3.4 Minimum requirements of paving in various areas

a. Paving within Process & Utility areas for maintenance compatible to crane movements / dropout / Loading / Unloading areas / Vehicular movement areas: Type – I (200 mm thick RCC)

b. Non vehicular movement areas

i. Unit: Type –II (150 mm thick RCC)

II. Offsite pump station: Type –II (150 mm thick RCC)

II. Bullet Area: Type –II (150 mm thick RCC)

II. Utilities: Type –II (150 mm thick RCC)

c. Pipe rack: PCC 1:3:6 (100 mm thick)

Paving and trenches including covers in process units shall be suitable for Hydra crane movement. Where movement of bigger cranes for maintenance is envisage paving and trenches including covers shall be designed for the loads arising from the same.
### 2.4 SURFACE TREATMENT

The surface treatment for the various areas shall be provided as enumerated in the table below.

<table>
<thead>
<tr>
<th>AREA</th>
<th>RCC PAVING</th>
<th>ASPHALT PAVING</th>
<th>50 thick PCC 1:3:6 ON 115 thick brick soling</th>
<th>GRAVEL 100 THK PCC 1:3:6</th>
<th>ACID / ALKALI PROOF COATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Areas of Process units (including Roads for crane movement)</td>
<td>X (Type I /II Paving as per cl. 2.3.4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Around Transformers In substation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roads (excluding roads having crane movement)</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approaches to units</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank farms</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Acid / alkali / storage / handling area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Parking</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardstands</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Pathways</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe ways</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

'X' Indicating applicable option

**Notes:**

1. Existing services where interfering with the new construction should be located and rerouted as instructed by Owner / Consultant.
2. Micro-grading shall be carried out by the Contractor over graded areas to bring the FGL to indicated levels including provision of required slopes and finishes.
2.5 STORM WATER DRAINAGE

2.5.1 Storm water drains shall be sized for the higher discharge arising out of either rain water or fire fighting water.

2.5.2 Rain water run-off shall be computed by the formula:-

\[ Q = \frac{KIA}{360} \]

K is run-off coefficient given below.
A is area (hectares) contributing to the drain
I is rain fall intensity (mm / hr.)
Q is the discharge.

2.5.3 Design of drains shall be based on Manning’s formula:-

\[ V = R^{2/3} S^{1/2} / n \]

V is velocity of flow m/s,
R is hydraulic radius,
S is slope,
n is roughness coefficient taken as 0.013 for plaster surface, 0.015 for cast-in-situ concrete, 0.017 for brick lined.

The following parameters are to be ensured to be within limits specified while sizing

Minimum velocity of drains : 0.6 m/s
Maximum velocity of drains : 2.4 m/s
Minimum depth of drains : 300 mm
Minimum width of rectangular drains : 300mm (for depth<500mm)
Minimum width of drains : 500 mm (depth > 500mm)

Run off coefficient ‘K’

a. paved area concrete - 1.0
   Bituminous - 0.9

b. unpaved areas - 0.7

c. unusable areas like Green belt - 0.4
2.5.4 Drains within Process Units

Rain water falling on such portion of paved areas of process unit where it is not likely to get contaminated, shall be collected in open rectangular RCC drains. These drains shall be covered by gratings, and shall be generally connected to periphery drains, which at battery limit shall have a double valve chamber. This will permit discharging the rain water either to storm water network, or to the battery limit CRWS manhole. Drains shall be designed for the maximum of rainwater / firewater on same principles as storm water drains.

2.5.5 Culverts and Road/Rail Crossings

Road / Rail and storm water drain crossing shall by RCC box culverts, designed for the Relevant IRC loads for roads, and track loads for rail. The relevant lateral loads due to wheel / track loads on the soil adjacent to wall on crossing shall be considered on the walls. Approval from the rail authorities on culvert design shall be in the scope of LSTK contractor.

Drain to adjacent to roads / pavement where heavy crane movement is anticipated shall be Concrete drains, designed to resist the lateral thrust due to wheel loads.

Pipe culverts, if instructed to use by Owner/PMC, shall comprise of R.C.C. pipes (class NP-3, IS: 458) under roads; and R.C.C. pipes (class NP-4, IS: 458) under rail lines.

2.5.6 Tank Farm Drainage

Tank farm drainage system should be provided in such a way that the storm water discharge shall be either sent to storm water open ditch or to the oily water sewer by providing valve pit outside the dyke wall depending on its contamination.
2.5.7 Disposal of Storm Water

Storm water drains shall not be combined with oily waste sewer / CRWS/combined sewer system, etc. For disposal of storm water references shall be made to the ‘scope’ document.

2.5.8 Oil Catcher

An oil catcher with baffle wall type arrangement shall be provided a storm water ditch before it leaves the battery limit of the unit, & tank farm.

2.6 WATER SUPPLY

Existing drinking water piping shall be extended to new facilities. Adequacy of header branch line etc. shall be ensured; else additional lines shall be run.

2.7 SANITARY SEWEIRS

2.7.1 General

Sanitary sewerage will not be combined with storm water.
Building drainage shall be designed as a dual pipe system with separate soil & waste pipe.

Sewers shall be designed for discharging 3 times average flow flowing half full in case of lateral sewer, and flowing 2/3 full in case of Main sewer. The minimum and maximum clearing velocities shall be 0.75 m/s and velocity 2.4 m/s respectively. Velocity shall be calculated by Manning’s formula with n=0.015

Minimum pipe size shall be 100 mm and all pipes shall preferably be salt glazed stoneware unless abnormal soil conditions or high velocity dictates otherwise.

2.7.2 Sanitary sewer shall be led into the sewerage system leading to waste water treatment plant (WWTP). Where system is not available, septic tank/soak pit shall be provided.
2.7.3 Cover for Sewer Line shall be minimum 600 mm.

Under road, sewer shall be protected by concrete encasement or minimum cushion shall be 1200 mm.
Under railway, the sewer shall be protected as per railway standards.

2.7.4 Material of Construction


b. Material of Construction for Sewer

Sanitary Sewer
i. Toilet block to inspection - CI pipes as per IS: 3486/1729) or UPVC, as directed.

ii. Gravity main & lateral - Salt glazed stoneware / C.I. / R.C.C. Class P1 (as per IS: 458)

iii. Pressure main - C.I. pipes (as per IS: 1536 and IS: 1537)

iv. Offsite Pumping, if any - CPVC pipes/GI as per PMS J2A(as directed)

v. Manholes - R.C.C. M30

2.8 CONTAMINATED RAIN WATER SEWERS

2.8.1 Process Unit

Contaminated rain water / floor wash / fine water shall be collected through catch basins located in the contaminated areas of the process unit and shall be send to the oil catcher / CRWS pit / CRWS header. The continuously contaminated area of all pumps shall be segregated by kerb wall; discharge from such kerbed areas shall be collected in OWS network and not in CRWS network.
CRWS shall be designed for contaminated water due to rain water or Fire water, whichever is more.

The quantities of contaminated rain water shall be worked out based on the contaminated process area in the unit block.

Sewer shall be sized flowing full with peak flows taking future requirements or 2/3 full without future requirements.

CRWS manholes shall be R.C.C. (M30) construction. For trapping of gas or prevention of spread of fire through CRWS from one area to another, a liquid seal of minimum 150 mm shall be provided in manhole along with suitable vents. Location of sealed manholes should be decided accordingly. The vents on the manholes should extend minimum 2.0 m above the pipe rack or 1.0 m above buildings, or if in open areas extending min 3.0 m above FGL with frame arresters.

CRW sewers in process units and tankage areas shall be of mild steel /Carbon steel conforming to IS: 3589

2.8.2 Tank Farm Area

Tank farm areas, not containing tanks for corrosive materials, shall be drained by surface drains. Waste water shall be led to a sand trap and then to a valve chamber which shall either drain the water to storm water drain or oily water drain. Waste water from tank farm areas containing corrosive / hazardous materials shall be drained by chemical sewers to neutralization tank / ETP.

2.9 OTHER PROCESS DRAINS

Other process drains shall be oily water sewers, closed blow down sewers or chemical Sewers. Sizing, layout, material specification, corrosion protection etc will be as per u/g piping design Basis.
Oily water sewer convey water contaminated with oil, e.g. from reflux drums, separators, Cooling / quench water for compressor / pump, process wash water, floor and paving Drains in oily areas etc. These are conveyed either to WWTP or oil separator by means Of U/G steel pipes through sealed manholes.

Blow down are liquid streams containing water / oil / chemicals that are required to be drained from process equipment under different operating situations like start-up, shutdown etc. Blow down systems are closed piped systems in which streams are collected in underground blow down drums and then pumped to respective slop / field tanks.

Chemical sewers carry effluents containing chemicals which require separate treatment from oily water streams. These are generally corrosive and require pipe of materials resistant to corrosion or lined pipes.

Closed blow down sewers shall be closed piping systems as shown in piping drawings. These will lead to underground blow down drum / drums which shall be protected by a concrete pit as detailed in drawings. Before entering the blow down drum, a valve chamber shall be provided for the sewer. Sewer cleanouts will be provided at start / end charges in direction and at 45 m intervals on straight length.

Other aqueous blow downs within process areas will be collected by funnels and routed through oily water sewers to sealed manholes. A common oily water header will route these streams to the plant oily water sewer network leading to waste water treatment plant.

Small neutralization pits shall be provided near battery rooms to treat floor wash in battery rooms. Water from these pits will further be routed to storm water drains.

Dyked areas around emergency booths shall drain into a gully trap which shall be connected to the chemical sewer network.
Oily water & contaminated rain water catch pits / manholes shall be of reinforced concrete to the chemical sewer network with internal coal tar epoxy lining.

Manhole for acid / alkali sewer shall be of reinforced concrete (M30). Exposed steel work shall be provided with coal tar epoxy coating.

### 2.10 STORAGE TANK FOUNDATION AND DYKE WALLS

2.10.1 The storage tank foundations shall be designed to sustain the forces at the tank bottom within permissible settlement, under operating and hydro-test conditions.

Tanks less than 2.5m dia. may rest directly on a concrete pedestal with anticorrosive layer.

Tanks greater than 2.5m dia. but less than 10.0 m dia. may be supported on RCC ring all with sand / murrum fill.

For tanks greater than 10m dia, Tank Pad Foundations shall be provided as per relevant design Codes.

2.10.2 Anticorrosive layer shall be provided as per specifications for tank pads of 50 thick premix Carpet over 50 thick bitumen sand mixed with additions of kerosene / oil as required.

2.10.3 Storage tank Dyke Walls / Fire Walls

Dyke walls / Fire walls shall be provided. Walls shall be plastered brick work conforming to standard relevant Codes. DYKE walls shall be designed for retaining liquid in case of rupture of the largest tank in the farm. It shall be minimum 600mm thick to enable persons to walk on the wall top. If space permits, Dyke walls shall be provided with ramps on both sides at suitable places, for movement of vehicles for tank cleaning purpose. Fire walls shall only be 600 mm high (min.) or as shown in drawings / as instructed. They shall only retain spillages, to prevent fire spread.
2.11 BARRICADE

Contractor shall design a suitable barricading system for protection of existing facilities if required. Barricade shall be of G.I. sheet cladding with suitable supporting system of height and extent shown in drawings or as instructed by Owner / Consultant. Water spray system shall be incorporated where felt necessary by Owner / Consultant. Localized G.I. sheet barricading shall be provided from operational constraint requirements as directed by Owner / consultant.

2.12 TRENCHES

Trenches shall be of RCC with inserts or other suitable arrangement required to support Cables pipes etc. Pre-cast concrete covers with lifting arrangement shall be provided on top. In paved areas, the top will be flush with finished floor level. Covers shall overlap walls and joints with paving shall be sealed to prevent water entry. In unpaved areas, walls shall be raised above ground level by 100 mm. Trench floors shall be provided with a nominal slope to drain pits, where any water entering trenches can collect and be detained to the nearest contaminated rain water sewer / storm water sewer. Trench covers shall be designed for the vehicle load relevant to the area where the trench is located. Cable trench shall be of leak proof construction.

2.13 HARD SURFACES

Hard surface of PCC 1:3:6, (100 mm thick) over suitable bedding (brick / stone soling) Shall be provided below all new pipe tracks and / or extended potion of existing pipe Tracks (if any). This shall extend 600 mm on one side for track width less than 6 m, and 900mm On either side for pipe track having width 6 m or more, end it shall have approach @ 500 M c/c from nearest road.

Hard surface of PCC 1:3:6 (100 mm thick) over suitable bedding (brick / stone soling) of approximate size 1 m x 1 m shall be provided with proper approach near drain point of offsite piping, near drinking water installations, at washing facilities,
etc., with suitable curbing and drainage arrangements as required for the fluid being handled.

2.14 REMOVAL / REROUTING OF OBSTRUCTIONS

All underground or above ground structures / foundations which will cause obstruction to new structures / foundations, and which can be removed without disturbing any functions of the existing structures if any, shall be removed by the Contractor.

All existing underground or above ground facilities requiring rerouting due to fouling with new facilities shall be rerouted by the Contractor in such a manner that rerouted facilities keep on functioning as before.

Before finalizing the route connection to existing system, adequacies of existing system shall be checked by the contactor.
ANNEXURE- III

CIVIL ENGINEERING DESIGN BASIS

(STRUCTURAL)
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1.0 GENERAL

1.1 SCOPE

This engineering design basis defines the minimum design criteria that shall form the basis for carrying out detailed structural design and engineering of all plant and non-plant structures and buildings. All data required in this regard shall be taken into consideration for acceptable, satisfactory and trouble-free engineering of the structures.

Compliance with this design basis and/or review of any of the contractor documents shall in no case relieve the contractor at the contractual obligations. All structures shall be designed for the satisfactory performance of the functions for which they are being constructed.

1.2 UNITS OF MEASUREMENT

Units of measurement in design shall be in metric system.

1.3 DEFINITIONS

Owner  
Talcher Fertilizers Limited (TFL)

Consultant  
To be selected

LSTK Contractor  
Successful LSTK bidder of the tender

CCE  
Chief Controller of Explosives

TAC  
Tariff Advisory Committee

NFPA  
National Fire Protection Association

IS  
Indian Standards
1.4 CODES AND STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country.

1.4.1 The main codes and standards and statutory regulations considered as minimum requirements are as follows Latest revision of these shall be followed.

1) National Building Code of India : 2005
2) IS: 875 (Part 1) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 1 – Dead Loads).
3) IS: 875 (Part 2) - Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 2 – Imposed Loads).
4) IS: 875 (Part 3) - Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 3 – Wind Loads).

1.4.2 STRUCTURAL STEEL

1) IS: 800 – Code of Practice for General Construction in Steel
2) IS: 802 – Code of Practice for use of structural steel in overhead transmission line towers.
3) IS: 1161 – Code of Practice for Circular hollow sections/pipes.
4) IS: 4923 – RHS & SHS sections.
5) IS: 2629 – Recommended practice for hot dipped galvanizing on iron and steel.
6) IS: 2633 – Methods for testing uniformity of coating of zinc coated articles.
7) IS: 6533 – Code of Practice for design and construction of steel chimney.
8) IS: 6745 – Method for Determination of mass of zinc coating.
9) IS: 814 – Covered Electrodes for manual metal arc welding of Carbon and carbon manganese steel.
10) IS: 816 – Code of Practice for use of Metal arc welding for General Construction in mild steel.
11) SP-06 – (Part 1 to Part 7)- Handbook for Structural Engineers.

### 1.4.3 REINFORCED CONCRETE AND MASONRY WORK

1) IS: 456 – Plain and Reinforced Concrete – Code of Practice
2) SP: 16 - Design Aids for Reinforced Concrete to IS: 456
3) SP: 34 – Handbook of Concrete Reinforcement and Detailing.
7) IS: 2950 (Part 1) – Code of Practice for design and construction of Raft foundation.
8) IS: 2974 (Part 1 to Part 5) – Code of Practice for design and construction of Pile Foundations.
9) IS: 3370 – Code of Practice for Concrete Structures for storage of liquids.
10) IS: 4326 – Code of Practice for earthquake resistant design & construction of buildings
11) IS: 13920 – Code of Practice for ductile detailing of reinforced concrete structures subjected to seismic forces.
12) IS: 1172 - Code of basic requirements for water supply, drainage & sanitation
13) IS: 1742 - Code of practice for building drainage
14) IS: 1905 - Code of practice for structural use of unreinforced masonry
15) IS: 2212 - Code of practice for brick work
1.4.4 ROADS AND SANITARY WORKS

1) IS: 2065 - Code of practice for water supply in buildings
2) IS: 8835 - Guidelines for design of surface drains.
3) IRC: 6 - Code of practice for road bridges, Section-II Loads and stresses
4) IRC: 19 - Standard Specifications And Code of Practice for Water Bound Macadam
5) IRC: 37 - Design of flexible pavements
6) IRC: 58 - Design of rigid pavements

Note: The above list is suggestive and not exhaustive. Apart from these basic codes any other related codes shall also be followed wherever required.

In case of any difference between Codes provision and this design basis, the stringent one should govern the design.

1.4.5 In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows.
- Statutory Regulations
- Job Specifications
- Engineering Design Basis
- Standard Specifications

2.0 MATERIALS OF CONSTRUCTION

<table>
<thead>
<tr>
<th>Type of Structure</th>
<th>Materials of Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piperacks</td>
<td>Structural Steel (unless required otherwise from process requirement or operation considerations)</td>
</tr>
<tr>
<td>Technological Structures/Platforms</td>
<td>-do-</td>
</tr>
<tr>
<td>Shed type structures (e.g. compressor shed, Pump shed)</td>
<td>-do-</td>
</tr>
</tbody>
</table>
Opening Platforms in steel structures | Steel gratings
--- | ---
Blast Proof Control Room | RCC
Substation | RCC framed with hollow/solid concrete blocks walls

### 3.0 DESIGN LOADS (DL)

The following design loadings shall be considered:

1. Dead loads including self weight
2. Live load
3. Wind load
4. Seismic load
5. Equipment load
6. Dynamic load
7. Load from lifting appliances
8. Erection loads / maintenance loads
9. Thermal load
10. Earth pressure / Hydrostatic Loads
11. Any other load not mentioned above, but applicable

These loadings shall be applicable to all structures irrespective of the material employed for construction.

### 3.1 DEAD LOADS

Dead load shall comprise of the weight of all permanent construction including walls, fire proofing, floors, roofs, partitions, stairways and fixed services. Unless noted otherwise following unit weights shall be adopted.

- Reinforce Concrete : 2500 kg/m³
- Plain Concrete : 2400 kg/m³
- Structural steel : 7850 kg/m³
- Backfill Soil : 1800 kg/m³
- Operating floor with grating : 100 kg/m²
- Staircase (steel) : 140 kg/m²
- Ladder : 40 kg/m²
3.2 EQUIPMENT LOADS

- **EQUIPMENT CATEGORY I**
The weight of equipment category I such as pumps, compressors, motors etc., shall be derived as far as possible from Manufacturer’s data and shall include controls, auxiliary machinery, piping etc. The equipment load shall be categorized if required for use in various loading combinations as empty and operating.

- **EQUIPMENT CATEGORY II**
This category consists of loads from equipments such as vessels, columns, heat exchangers, condensers, settlers, filters and the like, complete with their piping. In accordance with the various load combinations for the category of equipment, the following weights/loads shall be included in the calculations.

  a) **EMPTY WEIGHT (ELe)**
  This is the dead weight of vessels, columns, etc. completely installed) including platforms and ladders, piping, insulation and fireproofing) and ready for operation, however, without liquid filling. Weights will be derived from manufacturer’s data.

  b) **OPERATING LOAD (ELo)**
  This is the empty weight plus the maximum weight of contents of vessels, columns, etc. during normal operation of the plant, Weight of pipes full of product (liquid/gases) plus the weight of insulation and anchor loads if any.

  c) **HYDROSTATIC TEST LOAD (ELt)**
  When Hydrostatic pressure testing of equipment is required at site and is done after installation, the weight of equipment, completely filled with water shall be incorporated in the design of the supporting structure. Only one biggest system shall be considered to be tested at a given time.

  The empty / operating / test weight of process equipment including contents and all fixtures, platforms, ladders and attached piping etc, shall be considered. If
piping weight is not indicated separately or not included in the weight of the equipment, the same shall be taken as 10% of the weight of the equipment.

3.2.1 Exchangers / Fabricated equipments

When exchangers are supported on structures, the supports shall be designed for vertical and horizontal forces (bundle pulling force or friction forces). The vertical loads shall be categorized into empty weight, operating weight and test weight. Weight distribution over two (2) saddles of an exchanger shall normally be as follows:

<table>
<thead>
<tr>
<th>Exchanger Type</th>
<th>Channel Side</th>
<th>Shell Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floating head type</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>Fixed tube sheet type</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Kettle type</td>
<td>45%</td>
<td>55%</td>
</tr>
<tr>
<td>U-tube and other type</td>
<td>67%</td>
<td>33%</td>
</tr>
</tbody>
</table>

3.2.1.1 Special Considerations

a. Bundle Pull

Bundle pull forces for different types of exchangers shall be taken as under:

- Fixed type - Nil
- Kettle type - 0.30 x Bundle weight
- All other types - 0.86 x Bundle weight or 30 N/mm of diameter whichever is greater.

Total Bundles Pull shall be considered on fixed pedestal alone

b. Thermal Expansion

Horizontal force due to thermal expansion of horizontal vessels / exchangers shall be relieved by using slotted holes and slide plates and remaining force derived from the product of the sliding saddle ‘gravity load’ and the coefficient of friction shall be applied to each support. The coefficient of friction shall be as under:
c. Non-Static Loading

Foundations and structures supporting vessels subject to surge loading, such as De-aerators shall be designed with sufficient stiffness and rigidity to resist a notional horizontal forces of 10% of those derived from the Vessel’s operating weight or the given surge load whichever is the greater. The forces shall be applied at the vessel’s centre of gravity and act longitudinally OR transversely. Consideration shall be given to bracing these structures.

The design of foundations and structures supporting agitated vessels, centrifuges, reactors and other variable load equipment shall take full account of all the loading data provided by the equipment vendors. Where no loads are available, consideration shall be given to applying force at 10% of operating weight. In addition, for dynamic effect loads will be increased by 50% of steam agitated equipment and 25% for mechanical agitated vessels.

Where two or more similar items of such equipment are supported on a common foundation or structure, the design must be based on the assumption that these items will resonate in phase.

3.3.2 Rotating Equipment

Comprehensive loading data of mechanical equipment, such as, fans, blowers, pumps, compressors, D.G. Sets, turbines, motors engines etc., as furnished by the equipment vendor shall be considered.

3.3 LIVE LOADS (LL)

Live loads shall, in general, be as per IS: 875. However, the following minimum live loads shall be considered in the design of structures to account for
maintenance and erection phases; if equipment layout / vendor drawings indicate loads of greater magnitude, the same shall be adopted.

i. Process Building / Technological Structure (Open / Enclosed type)
   - Operating area: 5.0 kN/m²
   - Maintenance area: 7.5 kN/m²
   - Ground floor: 10.0 kN/m²

ii. Compressor House/TG House
   - Operating area: 10.0 kN/m²
   - Maintenance area: 10.0 kN/m²
   - Ground floor: 10.0 kN/m²

iii. Service Platform
   - Vessel / Tower: 3.0 kN/m²
   - Isolated platform: 2.5 kN/m²
     (For valve operation)
   - Access way: 2.5 kN/m²
   - Cross over: 2.0 kN/m²
   - Piperack walkways: 2.5 kN/m²
   - Gantry girder walkway: 3.0 kN/m²

iv. Substation / Control Room
   - Panel floor: 10.0 kN/m²
   - Miscellaneous partition: 1.0 kN/m²
   - Other areas: 5.0 kN/m²

v. Office building
   - Office area: 3.0 kN/m²
   - Entrance lobby: 5.0 kN/m²
   - Exit way: 5.0 kN/m²
   - Miscellaneous partition: 1.0 kN/m²
vi. Laboratory
   Upper floors - 4.0 kN/m²
   Ground floor - 5.0 kN/m²

vii. Cooling Tower
   Operating platform / cover - 3.0 kN/m²
   Slab of hot water basin & Sump

viii. GT Building / DM Plant / ETP
   Operating platforms - 3.0 kN/m²
   Ground floor - 5.0 kN/m²

ix. Staircase
   Process Building - 5.0 kN/m²
   Technological structure - 5.0 kN/m²
   Office - 5.0 kN/m²
   Substation/Control Room - 3.0 kN/m²
   Laboratory - 4.0 kN/m²
   Service platform - 2.5 kN/m²

Loads on account of equipment and incidental loads shall be taken over and above the loads indicated in the table.

For all other buildings not covered in above Table as well as roofs of various structures, the imposed loads shall be taken as specified in IS: 875 (Part II)

1 KN/m² allowance shall be made for services supported from below the floor.
Live load on various types of roofs shall be as per the requirements given in IS: 875.

3.4 WIND LOADS (WL)

Wind loads shall generally be as per IS-875 (Part-3) except for switchyard structures and transmission towers for which IS: 802 shall be applicable. Basic wind speed shall be as per the Code. As per IS:875 (Part-3), definition of basic wind speed shall be peak gust velocity averaged over 3 second time interval at 10 m height above mean ground level with 50 years mean return period. The design life span of all structures, except temporary structures, and boundary wall shall be taken as per IS 875. Life span of temporary structures and boundary wall can be lesser and shall be as per IS: 875.

Design wind speed and pressure shall be worked as per the latest revision of IS 875 Part-3.

To account for surface area of piping, platforms and other attachments fixed to the equipment, the surface area of the equipment (vessel/column) exposed to wind shall be increased by 20% or as specified in the mechanical data sheets of the equipment.

Wind force on structural elements shall be calculated using design wind pressure multiplied by elements frontal area, normal to wind direction multiplied by force coefficient as per Table 26, IS 875 Part-3.

In calculation of wind force frictional drag shall be considered where applicable.

3.5 SEISMIC LOADS(SL)

Seismic loads shall be as per IS: 1893 (latest version).

3.6 IMPACT AND VIBRATORY LOADS

Structures subjected to impact or vibratory loads shall be designed as per the provision of IS: 875 & IS: 2974. Requirements for monorails and overhead cranes
shall be as per IS: 800, IS: 875 or manufacturer’s data, whichever is more stringent.

3.7 BLAST FORCES

Blast resistant Control Room or any other specified structure, subjected to blast forces generated due to accidental blast from hydrocarbon ignitions should be designed to withstand all such forces. Unless specifically mentioned by the process licensor, design blast loads and blast resistant construction shall be as specified below and shall conform to relevant IS codes and good engineering practices.

Buildings located within 30 m from a potential blast source, shall be designed to withstand the maximum combination of loads resulting from any one of the following:

1) Blast pressure equivalent to static pressure 21KPa acting on all exterior surfaces.
2) Suction blast pressure equivalent to static pressure 7 KPa acting on all extreme surfaces.

Design of blast resistant control building shall be according to the following minimum blast-loading conditions:

Condition 1:
Any of the following combinations:
1A, 1B, 1C whichever is the most critical
21 KPa on walls and roof.
Condition 2:
7KPa on interior wall and roof surfaces.

Control buildings located more than 30 m from a blast source shall be designed to resist maximum combination of loads in accordance with the following table:

### Distance versus Design Pressure

<table>
<thead>
<tr>
<th>Distance from Process Equipment (meter)</th>
<th>Blast Pressure (KPa)</th>
<th>Suction Blast Pressure (KPa)</th>
<th>Wind Velocity Pressure (KPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 to 45</td>
<td>21</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>45 to 60</td>
<td>10</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>60 to 75</td>
<td>7</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>75 to 150</td>
<td>3</td>
<td>1</td>
<td>*</td>
</tr>
<tr>
<td>Over 150</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

### Structural Design Criteria

- Design the structure as a shear wall structure with the roof acting as a horizontal diaphragm that transfers the transverse loads to the side shear walls. External shear walls shall be continued up to 1.5 m below GL or up to founding level whichever is less.
- Design of walls and roof shall be based on the “Yield Line Theory”.
- Provide cast-in-situ reinforced concrete walls and roof of load-bearing type, designed to resist bending and transmit horizontal shear. Precast concrete panels may be used but shall be either mechanically bonded to cast-in-situ reinforced concrete columns or provided with built-in load transmitting steel plates or angles so that the panels can be welded in place.
- Anchor walls to foundations and concrete roof slabs with steel reinforcing bars to provide full moment connections.

Provide roof framing with adequate bearing and good anchorage to the supporting walls. Weld roof form decking if used to the top member of the roof frame.
- Distribute loads on roofs and walls in two directions where possible.
- Consider stress reversals at each member and provide a minimum 20% stress reversal.
- Design reinforced concrete members with good ductile properties. Limit tension steel to 1% of the concrete area and 2% of the concrete area for tension plus compression steel. To allow for stress reversal provides reinforcing steel in both concrete faces and set shear bars perpendicular, not inclined.
- Provide local strengthening of concrete at opening by additional reinforcing without local thickening where possible.

Load combinations with blast loads
- For Flexure
  1.0 (Dead load + Blast load)
- For shear
  1.2 (Dead load + Blast load)
Live load shall not be considered on the roof during blast.

Soil Bearing Capacity
Design bearing pressure shall be taken as equal to twice the allowable static bearing pressure for load combinations with blast load.

Stability Ratio
Factor of Safety in case of load combinations with blast load shall be as follows:
Overturning - 1.2
Sliding - 1.3

Openings:
- Minimize openings in the building enclosure and locate openings to avoid or be shielded from direct blast pressures.
- Windows, if unavoidable shall be limited in size and provided with special glazing.
- Select external doors, louvers and similar items, together with their frames, capable of withstanding the pressures. Do not use glass panels in these doors. Provide for personnel at least for two access doors, located remote from each other and where possible not in opposite walls. The size of equipment doors for maneuvering factory-fabricated control boards into or out of the control room.
3.8 CONTINGENCY LOADS

3.8.1 RCC Structures
All floor slabs and beams shall be designed for a concentrated load of 10 KN acting simultaneously with the uniform live load, but not with actual concentrated loads from equipment, piping etc. This load shall be placed to result in maximum moment and / or maximum shear.
This load shall not be considered for the design of columns, foundations and in overall frame analysis. For floor slabs, the load shall be considered to be distributed over an area of 0.75 m x 0.75 m.

3.8.2 Structural Steel
For process plants, the following contingency additional loading shall be applied to individual beam elements, these shall be applied as point loads to produce worst shear and bending stresses:

- Platform Walkways  3 KN
- Secondary Floor Trimmers  5 KN
- Primary / Grid beams  10 KN

3.9 MISCELLANEOUS LOADS
Apart from the specified live loads, possible overloading during construction / hydro-test maintenance / erection shall also be considered in the design Job specifications shall also be referred to, for any specific loading.

Hydrostatic pressure shall be adequately accounted for, in the design of structures, below ground water table.
All the handrails, parapets, parapet walls, balustrades shall be designed for horizontal load mentioned in Table 3 of IS-875 (Part-2).
3.10 LOAD COMBINATIONS

Structural analysis and design shall take into consideration, worst combination of the above loads under different phases, such as, Erection, Operation, Hydro-test, Shutdown, Maintenance, and Blast for control room, as applicable.

The design shall be governed by worst load combinations as per the procedures of relevant BIS codes.

4.0 DESIGN CRITERIA FOR FOUNDATIONS

4.1 GENERAL

Foundation sizing shall be based on working loads, not on loads which may have been increased by factors for the purpose of concrete design.

4.2 TYPE OF FOUNDATIONS

Type of foundations to be adopted and the pertinent details there of shall be as per provisions of scope and job specifications documents.

Following clauses describe the general guidelines to be followed while designing the foundations; these clauses do not per se stipulate the type of foundations to be followed.

4.3 SHALLOW FOUNDATIONS

4.3.1 For gravity loading, allowable net bearing capacity of soil shall be based on the following settlement criteria:

<table>
<thead>
<tr>
<th>Foundation Type</th>
<th>Allowable Settlement(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundations in unit areas, utility areas and Foundations for plant buildings including substation, Compressor house, control room, technological structures</td>
<td>25</td>
</tr>
<tr>
<td>Machine foundations and critical equipment with interconnected piping</td>
<td>25</td>
</tr>
<tr>
<td>Foundations supporting non-plant buildings</td>
<td>40</td>
</tr>
</tbody>
</table>
4.3.2 For transient loadings, such as wind / seismic, allowable net bearing capacity based on shear criteria may be considered.

4.3.3 For load combinations including wind, the Safe Soil Bearing Pressure may be increased by 25%.

4.3.4 For load combinations including earthquake, the Safe Bearing Pressure of Soil may be increased as permitted in IS: 1893.

4.3.5 Under blast (due to hydrocarbon explosion) load combinations if any, the design bearing pressure of soil shall not exceed twice the allowable static bearing pressure of soil.

4.3.6 Allowable Loss of contact area between underside of foundation and soil (due to resultant Overturning Moment) under different loading conditions shall be as given below.

<table>
<thead>
<tr>
<th>Load Combination description</th>
<th>Allowable % Loss of Contact Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Operating Load case (Plant operating, with or without Live Loads, for worst cases)</td>
<td>0 % to 10%</td>
</tr>
<tr>
<td>Operating Load Case with Wind or Earthquake (with or without Live Loads, for worst cases)</td>
<td>up to 25%</td>
</tr>
<tr>
<td>B Operating Load case (Plant operating, with or without Live Loads, for worst cases)</td>
<td>0 % to 20%</td>
</tr>
<tr>
<td>Operating Load Case with Wind or Earthquake (with or without Live Loads, for worst cases)</td>
<td>up to 30%</td>
</tr>
</tbody>
</table>

Where

A = Foundations on Soil
B = Foundations on Rock
4.3.7 Soil and hydrostatic pressure on walls below grade.

In the design of walls below grade, provision shall be made for the lateral pressure of adjacent soil. Due allowance shall be made for possible surcharge from fixed or moving loads. When a portion or whole of the adjacent soil is below a free water surface, computations shall be based on the weight of the soil, diminished by buoyancy, plus full hydrostatic lateral pressure.

The lateral pressure from surcharge loads shall be taken in addition the lateral earth pressure loads.

4.3.8 Stability of foundations

Foundations shall be checked for stability against overturning, sliding & uplift. While checking against uplift, the following shall be considered.

**FOUNDATION DESIGN – FACTORS OF SAFETY**

<table>
<thead>
<tr>
<th>Type of Structures</th>
<th>Minimum factor of safety against overturning</th>
<th>Minimum factor of safety against Sliding</th>
<th>% Weight of Overburden over projected plan area of footing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With wind or seismic</td>
<td>Without wind or seismic</td>
<td>With wind or seismic</td>
</tr>
<tr>
<td>All Buildings/Structures / Eqpt. In Units</td>
<td>1.5</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Pipe Rack (Offsite)</td>
<td>1.5</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Flood Light Mast</td>
<td>1.5</td>
<td>-</td>
<td>1.5</td>
</tr>
<tr>
<td>Retaining Wall</td>
<td>1.5</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Over Head water tank</td>
<td>1.5(empty 2.0(full)</td>
<td>-</td>
<td>1.5</td>
</tr>
<tr>
<td>Blast Resistant Structures</td>
<td>1.5</td>
<td>2.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Flare supporting Structures</td>
<td>1.5</td>
<td>-</td>
<td>1.5</td>
</tr>
</tbody>
</table>

*50** means that the surcharge load is considered as 50% of the weight of the soil.
** In case area is paved, overburden shall be based on NGL (for area under filling) or 600 mm below HPP, whichever is lower. In case of unpaved area, it shall be w.r.t. FGL.

Minimum factor of safety against uplift shall be 1.2 for all structures. (Note: In case of sumps, lining weight shall not be included). Beneficial load of backfill can be included on in circumstances where it will never be removed.

Buoyancy from high ground water levels shall be taken into account in investigating stability against uplift.

### 4.4 PILED FOUNDATIONS

Piles shall be designed as per IS: 2911. However, pile capacity shall be proven by a sufficient number of initial load tests before preparing piling plans.

The increase in Safe Working Load permitted as per codal provisions, under load combinations including wind / earthquake shall apply equally to uplift and sheer conditions, subject to confirmations by the piling Contractor with respect to the particular piling system. Pile capacity may be similarly increased in blast condition to 1.5 times the permissible capacity under compression, tension and shear modes.

When any major machinery is to be supported on piles, behavior of the piles under dynamic, loading conditions, as established by necessary field test, shall be considered.

The capacity of pile groups shall be obtained by applying appropriate group efficiency factors. Where piles pass through filed ground, the available pile safe working load shall be suitably reduced to account for negative skin friction caused by settlement of fill. Where suitable, consideration shall be given to reducing drawdown effects by slip coating the piles.

While computing horizontal capacity, piles shall be treated as fixed head or free head depending on the degree of fixity at the top.
4.5 MACHINE/EQUIPMENT FOUNDATIONS:

Machine / Mechanical equipment foundations shall satisfy the requirements of IS: 2974 and any other parameters as per machine vendors.

Generally, foundations and structures supporting rotating machinery shall be so proportioned that their natural frequency shall not fall within the range of 0.8 to 1.2 of normal operating speed of the equipment. Further for major rotating machinery such as main compressor, the amplitude of foundation of structure during normal operation shall not exceed the allowable amplitude specified by the equipment manufacturer. The above consideration may be omitted for centrifugal pumps and fans and other minor rotating equipment weighing less than 1 ton or if the mass of the rotating parts are less than 1/100th of the mass of foundation installed directly on concrete provided that the weight of foundation is not less than 3 times of the equipment weight. In such cases, dynamic analysis is not necessary.

When dynamic analysis is called for, the combined centre of gravity of the machine and foundation system shall, as far as possible, pass through the centre of area of the foundation raft or centroid of the pile group. Wherever unavoidable, eccentricity shall be less than 5% for block foundations and 3% for frame foundations. However, in highly compressible soils, no eccentricity shall be permitted.

Foundations shall be so designed that natural frequency of the foundation system shall not resonate with the following:

a) Operating speed of the motor / turbine  
b) Operating speed of the machine  
c) 2 x Operating speed of the machine  
d) Critical speed of the machine (for centrifugal machines)
It shall be ensured that there is no transfer of vibrations from machine foundations to any part of the adjoining structures. In case such machines are sitting on building floors, approved damping pads shall be used with prior approval of the Owner / Consultant.

Where deviations (resulting from inaccuracies in soil parameter measurements, approximations in design method, etc.) from calculated natural frequencies, leading to amplitudes in excess of specified limits are foreseen, provision for increasing the foundation mass without removal of the machine and without affecting surrounding space availability or connected piping shall be made, if possible.

4.6 CONCRETE GRADE

Grade of concrete to be used in foundation shall in general be as per the philosophy adopted for the entire structure. Minimum cement content, type of cement and any remedial actions, if required for foundations due to aggressiveness of subsoil water, shall be as stated elsewhere in this document. For underground structures, such as, foundations, manholes M30 grade reinforced concrete shall be used.

4.5 FOUNDATION BOLTS

All holding down bolts or threaded rods for non-post tensioned applications shall be out of Mild Carbon steel conforming to IS: 2062 with Fy = 250 MPa unless Noted Otherwise. For scrubbing section and acid storage section, holding down bolts should conform to SS 316.

4.7.1 Minimum cover to Foundation Bolts

Minimum distance between a Standard Holding down Bolt or Anchor Sleeve and the face of Foundation/pedestal shall not be less than 6 x (dia of bolt) mm.
4.7.2 All equipment foundation bolts / templates shall be designed and supplied by equipment vendor. Foundation bolts for steel structures shall be designed and supplied by contractor as per standard drawings or approved equivalent.

4.7.3 Other Inserted And Embedded Items

Unless otherwise specified, all structural steel shall be weldable structural steel “Standard Quality” (Fe 410 WA), in accordance with code IS: 2062.

All embedded steel items (exposed to atmosphere) shall be hot-dip galvanized in accordance with IS: 2629, except if noted otherwise on the design drawings.

All inserted and embedded items shall be accurately placed or template in and be securely anchored prior to placing concrete.

At sliding ends of vessels and horizontal exchangers, sets of plain steel plates shall be provided. In order to reduce the horizontal force due to friction at sliding ends sets to PTFE bonded steel plates may be provided.

4.8 PEDESTAL HEIGHTS

Pedestals for structural columns : As per design requirement
Open paved area : 300 mm (min.) OR as indicated in Equipment Layout drawing
Open unpaved area : 300 mm
Covered area(building etc.) : 300 mm (min.) OR as indicated in drawing
Storage tank foundation : As per equipment layout

All equipment supporting foundations / pedestals

Open area : As required but not less than 300 mm
Covered area : As required but not less than 150 mm
Stair Pedestals : 300 mm (min.) OR as indicated in equipment Layout drawing.
Ladder pedestals : 300 mm

4.9 GROUTING
The minimum thickness of grout shall be 25 mm.
All anchor bolts sleeves / pockets and spaces under column bases, shoe plates etc. shall be grouted with free flow, non shrink (premix type) grout, with 28 days minimum cube crushing strength of 40 N/mm². Ordinary grout consisting of 1 part of OPC and 2 parts of clean, dry well graded sand mixed with water to obtain the required consistency shall only be used under the base plates of cross-overs, short pipe supports (not exceeding 1.5 m height) and small operating platforms (not exceeding 2 m height) not supporting any equipment.
For rotating equipment bases, (above 300 kw rating), grout shall be as per requirements of equipment vendor, as per the approved list / as per the decision of EIC.

5.0 DESIGN CRITERIA FOR REINFORCED CONCRETE STRUCTURES

5.1 GENERAL

a) All buildings, structures, foundations, machine equipment foundations, liquid retaining storage structures, trenches, pits etc. shall be of RCC and designed based on the following IS codes (latest revision with all amendments, issued there to) in general, and other relevant IS codes applicable: IS:456, 875, 1893, 1904, 2911, 2950, 2974, 3370, 4326, 4991, 4998, 5249, 6403, 8009, 13920.
b) Only limit state method as per IS: 456 shall be followed for the design unless otherwise specified elsewhere in this document for special structures.
c) All skeletal structures shall be of frame type construction, and detailing shall be as per provision of IS: 13920.
d) Where the specified design depth of groundwater table so warrants, all underground pits, tunnels, basements, etc. shall be leak-proof R.C.C. construction using water proofing compounds.

5.2 LIQUID RETAINING R.C.C. STRUCTURES AND BASEMENTS
5.2.1 All liquid retaining / storage R.C.C. structures shall be leakproof and designed as uncracked section in working stress method as per IS:3370. However, the parts of such structures not coming in contact with the liquid, shall be designed according to IS:456 except ribs of beams of suspended floor slabs and counterforts of walls (located on the side remote from liquid) and roof of liquid retaining structures which shall be designed as uncracked section. Hot/cold water basin, and other primary framing members of Cooling Towers and similar liquid retaining structures, which remain constantly in contact with water (stored / sprayed) shall be designed as uncracked sections. No increase in permissible stresses in concrete and reinforcement shall be made under wind or seismic conditions for such structures.

5.2.2 All liquid retaining / storage structures shall be designed assuming liquid up to the full height of wall, irrespective of provision of any overflow arrangement. Pressure relief valves or similar pressure relieving devices shall not be considered in underground water retaining RCC structures. Hot water basin in cooling tower shall be designed for the weight of water up to top of parapet wall.

5.2.3 Following conditions shall be also considered for design of liquid retaining structures, basement, trenches and other underground structure:-

a) Only water pressure from inside and no earth pressure, groundwater pressure or surcharge from outside wherever such a condition is likely to exist either in operation or during installation / testing.

b) Earth pressure, surcharge pressure or ground water pressure from outside and no water pressure from inside.

c) Base slab shall also be designed for the empty condition during construction and maintenance stages with maximum ground water table. Pressure Relief Valves shall not be used.

d) Intermediate dividing walls of pump sumps shall be designed considering water in one pump only and the other sump being empty for maintenance.
5.2.4 The walls and base slabs of liquid retaining storage structures shall be provided with reinforcement on both faces for thicknesses greater than 150 mm.

5.2.5 In all liquid retaining structures, PVC water bars (230 mm wide, 6 mm thick) shall be provided at each construction joint. PVC water bars shall be of minimum 150/230 mm width and 6 mm thickness, and generally shall be riffed/serrated type with a central bulb Kicker type PVC water bars shall be used for the base slab and in other areas where it is required to facilitate concreting. Material quality of PVC water stops shall confirm to IS 12200.

5.3 CONCRETE GRADE

All cast-in-situ structural concrete shall be Reinforced Concrete conforming to IS: 456. Minimum grade M30 shall be used for all sub-structures (foundations/ Pile foundations etc) except for grade slabs / paving for which M20 may be used. M25 grade shall be used for all super-structures. For compressor, M30 grade concrete shall be used.

Pre-cast concrete shall be of minimum grade M35.

From durability consideration the minimum cement content and maximum water-cement ratio shall be as follows:-

<table>
<thead>
<tr>
<th>Type of Cement</th>
<th>Plain concrete</th>
<th>Reinforced concrete</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum cement content (kg/m³)</td>
<td>Maximum water-cement ratio</td>
<td>Minimum cement content (kg/m³)</td>
</tr>
<tr>
<td>43 Grade-OPC</td>
<td>240</td>
<td>0.55</td>
<td>shall be as specified in IS 456</td>
</tr>
<tr>
<td>53 Grade-OPC</td>
<td>240</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>PPC</td>
<td>240</td>
<td>0.55</td>
<td></td>
</tr>
</tbody>
</table>

Maximum cement content shall not exceed 450 kg/m³.

If soil investigation report recommends high cement content and / or specified type of cement, the same shall have precedence.
75 mm thick PCC of grade M15 (nominal mix) shall be provided under all RCC foundations except under base slab of liquid retaining structures where 100 mm thick concrete of mix M15 (nominal mix) shall be used.

Concrete for encasing shall be M20 with 10 mm down aggregate.

Plain cement concrete (PCC) of grade M15 (nominal mix) of minimum 150 mm thickness shall be provided under all masonry wall foundations.

Plain cement concrete of grade M20 of minimum 40 mm thickness shall be provided as damp proof course, at plinth level of all masonry walls and to be coated with 3 mm thick bitumen emulsion.

Lean concrete of grade 1:5:10 shall be used as filler material wherever loose sub-grade exists by removing the loose soil/fill.

Any specific requirement regarding grade and thickness of PCC to be provided shall be incorporated in the drawing.

5.4 REINFORCEMENT BARS

HYSD Fe500 corrosion resistant bars confirming to IS: 1786 shall be used in foundations, piles and pile caps and super structures. The Minimum dia. used shall be 8mm. All structural steel and reinforcements shall be procured from SAIL / TISCO /RINL or Owner’s approved Vendor List.

Binding wire of 16 Gauge GI shall be used for tying the reinforcement conforming to IS: 280 unless specifically mentioned herein or in engineering drawings or other engineering design basis prepared for the individual units/structures.

5.5 MINIMUM THICKNESS OF STRUCTURAL CONCRETE ELEMENTS

For structural concrete elements, the following minimum thickness shall be followed:

<table>
<thead>
<tr>
<th>Footings (All types with or without beams)</th>
<th>300 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note: Tapered footings shall not have thickness less than 150 mm at the edges. Minimum average thickness shall not</td>
<td></td>
</tr>
</tbody>
</table>
### MINIMUM COVER TO REINFORCEMENT

The following minimum clear cover shall be provided to all steel reinforcement including links.

| Slab (roof & floors, canopy, cantilever, waist slab) | 30 mm |
| Beam (roof, floor tie, & lintel) | 30 mm or dia. of bar whichever is greater |
| Column, Pedestal | 40 mm above FGL, 50 mm below FGL |
| Retaining wall, Basement and Pit Wall |
| a. Face in contact with earth | 50 mm |
| b. Free face | 30 mm or dia. of bar whichever is greater |
| Liquid retaining structure |
| a. Face in contact with liquid | 30 mm or dia. of bar whichever is greater |
| b. Face away from liquid but in contact with earth | 50 mm |
| c. Free face | 30 mm or dia. of bar whichever is greater |
| Foundation slab, base slab, plinth beam | 50 mm |
Pile Cap

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Bottom face</td>
<td>100 mm</td>
</tr>
<tr>
<td>b. Top face</td>
<td>50 mm</td>
</tr>
</tbody>
</table>

5.7 **EXPANSION JOINTS**

Expansion points in concrete structures shall be provided at 30-35 m centers. The expansion joint shall be provided preferably by way of twin columns on a common foundation. Sliding joints shall be avoided as far as possible.

5.8 **DEFLECTIONS**

5.8.1 Deflections in concrete structures shall in general be limited by adherence to the limits on span by depth ratio for beams and slabs and length to lateral dimension ratios for columns as prescribed in IS: 456. Where special functional / serviceability requirements or large spans demand actual deflections and / or crack widths shall be calculated and the following limits adhered to:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total vertical deflection due to all loads including the</td>
<td>Span/250</td>
</tr>
<tr>
<td>Effects of temperature creep and shrinkage</td>
<td></td>
</tr>
<tr>
<td>Crack width (for non-liquid retaining structure)</td>
<td>0.3 mm</td>
</tr>
<tr>
<td>Crack width (for liquid retaining structure)</td>
<td>As per design requirement</td>
</tr>
<tr>
<td>Total horizontal deflection between two floors</td>
<td>Storey height/200</td>
</tr>
</tbody>
</table>

5.9 **MISCELLANEOUS APPLICATIONS**

5.10.1 **Admixtures**

Admixtures shall conform to IS: 9103 and to be mixed with concrete (if required) strictly as per manufacturer’s recommendations.

5.10.2 **Water for Construction**

Water used for mixing and curing shall be clean and free from injurious amounts of soils, acids, alkalis, salts, sugar, organic materials or other substances that may
be deleterious to concrete or steel. Portable water is generally considered satisfactory for mixing concrete. It should meet the requirement of IS: 456-2000.

5.10.3 Aggregates

These shall conform to IS: 383, specification for Coarse and Fine Aggregates from Natural resources.

5.10.4 Plinth protection

Each building shall be provided with 1.0 m wide concrete M10, 100 thick laid on 75 mm thick M7.5 concrete with 8 Tor @ 250 c/c both ways Reinforcement bars all round as plinth protection. A surface drain to be provided along-with plinth protection which shall be connected to the drainage system.

5.10.5 Ramps

Ramps for building entrance shall be cast in situ R.C.C. designed as a grade slab and the slope of ramps shall not be less than 1 in 10. Minimum thickness of the slab shall be 150 mm.

5.10.6 Hot Bitumen Paint

All underground structures including top surface of foundations shall be painted with two coats of hot bitumen paint of grade 20/30 with quantity of bitumen at least 1.2 kg/m² per coat.

5.10.7 Masonry Wall

a. All masonry walls from ground floor shall be placed on R.C.C. grade beams. However, light internal partitions may be placed on ground floor slab.

b. All brick masonry (M 7.5 MPa) grade walls shall be considered as 230 mm thick, except for partition walls which will be 115 mm thick. However, for fire barrier walls minimum thickness shall be considered as 350 mm.
c. All in-filled brick (M 7.5 MPa grade) panels shall be designed to transfer horizontal loads from wind and seismic to the structural frameworks without damage and the extent of brick panel dimensions shall be as per the recommendations in IS. All brickworks shall be provided with reinforcement consisting of 2 Nos. of 6 mm diameter bars at every fourth layer.

5.10.8 Anti-termite treatment

Anti-termite treatment shall be provided under all buildings as per IS:6313. Materials shall be as per IS: 8944.

5.10.9 Building Slabs on Grade

The specifications given in Table below are based on minimum requirements and shall be followed after proper design and requirement.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>DESCRIPTION</th>
<th>FLOORING TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td>1.a</td>
<td>Sub Grade</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Earth fill base compacted to 95% dry density</td>
<td></td>
</tr>
<tr>
<td>1.b</td>
<td>Rubble soling</td>
<td>230 Thick</td>
</tr>
<tr>
<td>2.a</td>
<td>Lean concrete 1:5:10 over 1.b layer</td>
<td>50 Thick</td>
</tr>
<tr>
<td>2.b</td>
<td>Structural Grade Slab</td>
<td>150 Thick</td>
</tr>
<tr>
<td></td>
<td>Stable in Grade M20 concrete (Reinforced with 8 mm dia bars @ 200 c/c both ways) over lean concrete</td>
<td>R/F placed centrally</td>
</tr>
<tr>
<td>3</td>
<td>Finish</td>
<td>Floor finish</td>
</tr>
</tbody>
</table>

TYPE I: Plant buildings such as Sub-stations, Control Rooms, Process Operators’ Room, Pump Houses, Utility Compressor Houses, D.M. Plant, E.T.P., Parking Areas, Stores, Porches.

TYPE III: Non Plant Buildings (viz. Administration, Laboratory, Canteen, Time Office, Gate House, Training Centre, Guest House, Residential Building)

Note: 1. Reinforcement steel shall be as per clause 5.5

5.10.10 Insulation

For equipment with temperatures over 200° C, or sub zero temperatures, insulation shall be provided between equipment base / lugs and concrete / steel structure.

6.0 DESIGN CRITERIA FOR STEEL STRUCTURES

6.1 GENERAL / DESIGN METHODS

6.1.1 Design fabrication and erection of the above work shall be carried out in accordance with the following IS Codes as applicable to the specific structures, viz, IS: 800, 801, 802, 806, 814, 816, 875, 1893, 6533, 9595, etc. Basic consideration of structural frame work shall primarily be stability, ease of fabrication/erection and overall economy, satisfying relevant Indian Standard Codes of Practice. Steel structures adequately braced in vertical and horizontal planes, consistent with functional requirements, shall be preferred over structure having moment connections. Moment connections, if adopted, shall be fully rigid as per IS:800. Where fully rigid joints are adopted they shall generally be confined to the major axis of the column member. Flare stack supporting structure shall be adequately braced on all four faces.

Structural elements, continuously exposed to temperatures above 200° C, shall be designed for reduced stress as per Table-4 of IS: 6533 (Part-2). The expected temperature of steel components shall not be allowed to exceed 400 ° C. The structures connected to column, heater vessels working at high temperatures shall not be rigidly connected with staircase and adjoining structures, which are on ambient temperatures.
6.1.2 Crane gantry girders shall generally be of welded construction and of single span length. Chequered plate shall be used for gantry girder walkway flooring.

6.1.3 Monorails shall be provided for all pumps and motors located in buildings, sheds and in open areas having rating more than 55 KW. For pumps and motors of smaller ratings, monorails shall be provided if directed by Owner / PMC.

6.1.4 Steel staircases shall have channels provided as stringers with minimum clear width of 750 mm and maximum slope of 41 degree. The vertical height between successive landings shall not exceed 4.0 meters. Treads shall be minimum 230 mm wide made of grating (with curved chequered plate nosing) spaced equally so as to restrict the rise to maximum 200 mm. If relevant local by-laws or applicable Factory Act Rules stipulates more stringent requirements in this regard, the same shall be adhered to.

6.1.5 Hand rails, 1000 mm high, shall be provided to all walkways, platforms, staircases. Toe plate (100 mm x 5 mm) shall be provided for all hand railing (except for staircases). Spacing of uprights shall be 1500 mm (maximum). Two types of hand railing shall be provided.

a. For walkways, platforms (except platform around/on circular & horizontal vessels), and staircases: Top rail, mid rail and upright shall be 32 mm dia. (NB) galvanized MS tubes.

b. For platforms around circular vessels: Top rail shall be 32 mm dia. (NB) galvanized MS tubes, but mid rail and upright shall be of structural steel.

6.1.6 Electro-forged/Welded hot dip galvanized MS gratings shall be minimum 25 mm deep. The maximum size of voids in the grating shall be limited to 30 mm x 55 mm. The minimum thickness of galvanizing shall be 120 microns. Gratings shall be suitable for the operation and maintenance loads for the floors.
6.1.7 Welded connections shall be adopted as far as practicable, except for cases where bolted connections are required viz. (Galvanized) electrical switchyard structures and transmission towers. Structural connections shall have minimum two bolts of 16 mm dia. unless otherwise limited by the size of members.

6.1.8 Lock nuts shall be provided for anchor bolts of tall structures, tall process columns, vibrating equipment, etc.

6.1.9 Minimum two nuts shall used for all anchor bolts except for ladder, stair and hand rail.

6.2 EXPANSION JOINTS

Expansion joints shall be provided at 80 – 100 m centres, where possible, column bracing shall be provided at the center of a longitudinal frame, rather than at the ends so as to avoid constraints on free expansion.

6.3 STEEL GRADE

Structural steel shall be of yield stress of 250 Mpa conforming to grade A of IS: 2062.

Tubular steel shall conform to Yst 310 of IS: 1161 & IS: 4923. Structural pipes shall be either seamless or mild welded. Spiral welded pipe is not acceptable.

6.5 LIMITING PERMISSIBLE STRESSES

- Permissible stresses in structural members shall be as specified in:
  - IS: 800 Hot rolled sections (excluding transmission towers and Switchyard structures).
  - IS: 801 Cold formed light gauge sections
  - IS: 802 Transmission towers & switchyard structures
  - IS: 806 Tubular Structures
- Permissible stresses in bolts shall be as specified in :-
  - IS: 800 Hot rolled sections
- IS: 801 - Cold formed light gauge sections
- IS: 802 - Transmission towers & switchyard structures
- IS: 806 - Tubular Structures

- Permissible stresses in welds shall be as specified in :-
  - IS:801 - Cold formed light gauge sections
  - IS: 806 - Metal Arc Welding

6.6 LIMITING DEFLECTION

a. The limiting permissible vertical deflection for structural steel members shall be as specified below :- (Where “L” represents the span)

<table>
<thead>
<tr>
<th>Structural Component</th>
<th>Limiting Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gantry girder for electric overhead crane (Capacity up to 50T)</td>
<td>L/750</td>
</tr>
<tr>
<td>Gantry girder for electric overhead crane (Capacity over 50T)</td>
<td>L/1000</td>
</tr>
<tr>
<td>Gantry girder for manually operated crane</td>
<td>L/500</td>
</tr>
<tr>
<td>Girder beam for supporting dynamic equipment/hoist</td>
<td>L/450</td>
</tr>
<tr>
<td>Grating / Chequered plate</td>
<td>L/200 or 6mm</td>
</tr>
<tr>
<td>Purlins supporting any type of roofing material under (dead load + live load) or (dead load + wind load) conditions</td>
<td>L/200</td>
</tr>
<tr>
<td>Other structural components</td>
<td>As specified in relevant IS Code</td>
</tr>
</tbody>
</table>

b. The limiting permissible horizontal deflection for multistoried steel structure/building including flare stack shall be Height/325.
6.7 MINIMUM THICKNESS

6.7.1 Structural Components

The minimum thickness of various structural components (Rolled Steel sections) shall be as given:-

a. General Construction

<table>
<thead>
<tr>
<th>Component</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trusses, Purlins, Side Girts, Bracings</td>
<td>6 mm</td>
</tr>
<tr>
<td>Columns, beams</td>
<td>7 mm</td>
</tr>
<tr>
<td>Gussets in trusses &amp; girders</td>
<td></td>
</tr>
<tr>
<td>i. Upto and including 12 m span</td>
<td>8 mm</td>
</tr>
<tr>
<td>ii. Above 12 m span</td>
<td>10 mm</td>
</tr>
<tr>
<td>Flare Trestles, Stiffeners</td>
<td>8 mm</td>
</tr>
<tr>
<td>Base plates</td>
<td>10 mm</td>
</tr>
<tr>
<td>Chequered plate</td>
<td>6 mm (on plain)</td>
</tr>
<tr>
<td>Grating</td>
<td>5 mm</td>
</tr>
</tbody>
</table>

b. Transmission tower and Switch yard structure

The minimum thickness of various structural components shall be as per IS: 802.

The minimum thickness for rolled beams and channels shall be mean flange thickness regardless of the web thickness.

The minimum thickness of tubes shall be as specified in IS: 806.

For structural members exposed to marked corrosive action, corrosion allowance shall be added as specified elsewhere, or otherwise suitably protected against corrosion.

The minimum thickness of structural components (except gratings & chequered plates) which are directly exposed to weather and inaccessible for repainting shall be 8 mm.
6.8 ELECTRICAL SWITCHYARD STRUCTURES AND TRANSMISSION TOWERS

All electrical switchyard structures and transmission towers shall have bolted connections, and designed on the basis of IS: 802.

6.9 PAINTING

Painting including shop primer to structural steel shall be Epoxy as per the painting specification for this project, included elsewhere in Technical Specification.

6.10 GROUTING

For structural columns : As required but not less than 25 mm
For equipment : As required but not less than 25 mm

6.11 CLADDING AND RAINWATER GUTTERS

All roof and cladding sheets should be galvalume sheet of 0.5 mm total coated thickness with 550 MPA grade steel confirming to AS 1397 with AZ150 grade coating.

Translucent sheets shall be provided, in non-process areas only, intermittently where day lighting is required. Rainwater gutters of Galvanized / Zinc coated sheets and UPVC rainwater pipes shall be provided for proper roof drainage.

7.0 CRITERIA FOR MASONRY WORKS

7.1 GENERAL

All masonry works shall be designed in accordance with IS: 1905, IS: 1597, IS: 2185, IS: 4326 and other relevant IS Codes as applicable. All external brick, stone and hollow concrete block masonry walls shall be of minimum 230, 350 and 250 mm thickness respectively. Hollow concrete blocks shall conform to IS: 2185. Masonry shall be plastered with CM 1:6, 12 mm thick on inside surfaces and 20 mm thick on outside surfaces.
7.2 CEMENT MORTAR

All masonry work shall be constructed in 1:6 cement sand mortar except half brick partition walls which shall be constructed in 1:4 cement sand mortar with two numbers of 6 mm diameter MS bars provided a every fourth course properly anchored with cross walls or pillars.

7.3 FIRE WALLS

Thickness of all masonry firewalls shall be as per Electricity Rules but not less than 345 mm.

8.0 DESIGN REQUIREMENTS FOR SPECIFIC APPLICATIONS

8.1 PIPERACK

For designing the pipe rack superstructure and foundation the following loads shall be considered:

8.1.1 Vertical Loading

Actual weights of pipes coming at each tier shall be calculated. In calculating the actual weight of pipe, the class of pipe, material content and insulation, if any, shall be taken into consideration. Insulation density shall be taken as 2600 N/m³ minimum. In case of gas / steam carrying pipes, the material content shall be taken as one-third volume of pipe filled with water. The total actual weight thus calculated, shall then be divided by the actual extent of the span covered by the pipes to get the uniformly distributed load per unit length of the span. To obtain the design uniformly distributed load, over the entire span, the u.d.l. obtained as above, shall be assumed to be spread over the entire span. However, minimum loading for any piperack shall not be less than 1.25 kN/m². In case, the calculated loading is higher than 1.25 kN/m², this shall be rounded off to the nearest multiple of 0.25 (i.e., 1.50, 1.75 kN/m²)
Vertical loads of flare pipe shall be taken as one third full of water for piping within units & one sixth full for outside unit battery line. All flare line independent support shall be of four legged braced open lower type construction.

In addition to piping load, gravity loads due to encasement, if any, shall be considered.

8.1.2 Friction Force (Longitudinal & Transverse)

Where the pipes are of similar diameter and service conditions, the friction force at each tier on every portal both in longitudinal and transverse directions, shall be 10% of the design vertical loading of the pipes for four or more pipes supported on a tier and 30% of the design vertical loading of the pipes, for single to three pipes supported on a tier. Longitudinal friction force shall be considered as uniformly distributed over the entire span of the beam at each tier and transverse friction force shall be considered as a concentrated load at each tier level. Friction forces on T-supports and trestles shall be taken as 30% of the vertical loading. Both longitudinal and transverse friction forces shall be considered to be acting simultaneously.

For two-phase fluid flow/transfer lines frictional force shall be minimum 50% of the weight of pipe including contents & insulation, acting simultaneously in transverse & longitudinal direction.

8.1.3 Anchor and Guide Force (Thermal Load)

Anchor and guide force (thermal load) in transverse and longitudinal direction shall be as per piping data.

8.1.4 Loading on intermediate Beam at Tier Level

Intermediate beam at tier level shall be designed for 25% of load on main portal beams in transverse direction. A reduction of 10% in vertical loading shall be considered for main portal beams, if intermediate beams are provided.
8.1.5 Loading on Longitudinal beams

Longitudinal beams connecting portal columns shall be sufficiently strong to sustain 25% of the load on the transverse beams. The total load shall be assumed as two equal concentrated loads acting at 1/3rd span. Other longitudinal axial forces coming on it from the design of the supporting system shall also be simultaneously taken into account in the design of the longitudinal beam. Friction & anchor forces, if specifically given by the Piping Specialist, shall also be catered for in the design. Loads from monorails, when supported from these beams, shall also be considered to be acting simultaneously along with all other loads mentioned above.

8.1.6 Cable Tray and Walkway Loads

The estimated actual load from electrical, instrumentation trays shall be considered at the specified locations, together with walkways, platforms for valve operation, wherever provided.

8.1.7 Wind Force

Transverse wind loading shall be calculated depending on the width of the piperack as per the following table. This force shall be considered irrespective of the height between two tiers.

<table>
<thead>
<tr>
<th>Width of Piperack</th>
<th>Wind Force at each Tier level (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 4 m</td>
<td>1.25 x p x s</td>
</tr>
<tr>
<td>Above 4 m but upto 6 m</td>
<td>1.50 x p x s</td>
</tr>
<tr>
<td>Above 6 m but upto 10 m</td>
<td>2.00 x p x s</td>
</tr>
<tr>
<td>Above 10 m</td>
<td>projected height x p x s</td>
</tr>
</tbody>
</table>
Where \( p \) = Horizontal wind pressure as per IS:875 (N/m²)

\( s \) = Spacing of portals (m)

For pipe racks of width greater than 10 m, the projected height shall be lesser of the following two:

i) \( 0.8 \times (\text{diameter of largest pipe including insulation (m)} + \tan 10^\circ \times \text{(width of rack (m))} \)

ii) \( \text{height between consecutive tiers} \)

8.1.8 For flare header or any other line supported on extended leg of piperack, the wind force shall be considered separately.

8.1.9 Seismic Loads

8.1.10 Seismic loads shall be as per IS: 1893 (latest version). Pipe racks should be adequately braced in all possible directions, consistent with function requirements.

8.1.11 Limiting permissible horizontal deflection for piperack shall be height / 325.

8.1.12 PLATFORMS BELOW AIR COOLERS

If handling pumps or other equipment is located below air coolers located on piperack or technological structures, blind floors shall be provided below air coolers, else, 2 m wide center platform with 3 m wide local extension below motors shall be provided.

8.2 RCC AND STEEL CHIMENY

RCC and steel chimneys shall be designed as per IS: 4998 and IS: 6533 respectively.
8.3 CULVERTS

Culverts shall be designed as per the following IRC codes of practices and manual. Where crane access is specified, the culverts shall be designed for the crane loads.

1. Standard specifications and code of practice for Road Bridges IRC 5
   (Section – I - General features of design)
2. Standard specifications and code of practice for Road Bridges IRC 6
   (Section-II – Load and Stresses)
3. Guidelines for Evaluation of Load Carrying Capacity of Bridges SP 37

Note: The above list is suggestive and not exhaustive. Apart from these basic codes any other related codes shall also be followed wherever required. This list is to be read in conjunction with the list of codes given in Civil Structural job specifications.
ANNEXURE- IV

GENERAL DESCRIPTION OF

STRUCTURES / FACILITIES
SCOPE
The dimensions & elevations of various units shall be furnished by LSTK contractor. All dimensions shall be finalized by the contractor during detail engineering phase & shall be got approved by Owner / PMC.

It is the contractor’s responsibility to design safe, sturdy and robust structures, foundations etc. to withstand all static and dynamic forces in accordance with design specifications and engineering specifications laid down in the document. The contractor should make suitable choice of foundations, e.g. isolated footings, raft foundation, pile foundation etc. depending on soil data, loads, settlement criteria.

The general description of structures / facilities shall be read in conjunction with the technical requirements & specifications given elsewhere in this document.

a) Compressor House
Structural steel shed with RC foundation, steel roof with monitor, S type louvers, G.I. pre-coated sheets roofing, eaves gutter with rain water down take pipes, G.I. pre-coated sheet cladding below eaves level, gantry girder for crane with walkway having handrail on one side with access ladders & open steel staircases for access at appropriate places.

RC deck mounted foundations for compressors with structural steel operating platform having HDG grating floor & handrail all-round, RC grade slab with flooring of type mentioned elsewhere, RC cable trench & RC floor drains at ground level.

b) Cooling Towers
The structure will be water retaining RCC structure and all construction joint shall be provided with PVC water stop, entire construction to meet relevant Indian Standard Codes requirement of water retaining structures.

Before the cooling tower is commissioned for use, it shall be tested for water tightness by filling it with water and allowing it to stand for 24 hours. It shall be topped up, if necessary and allowed to stand for a further period of 24 hours, during which the fall level shall not be more than 1.5 cm.
Inside wall shall be painted with two coats of coal tar epoxy over one coat of primer.

All nuts and bolts supporting the structure shall be of stainless steel.

All wooden structure/members of cooling tower shall be chemically treated must be conforming to relevant Indian Standard (IS) Codes for physical properties and for chemical properties.

Also the Process engineering specification should be followed.

c) Technological Structure

Open steel structure with RC foundations, structural steel platforms & floors at different levels with HDG grating, handrails all-round, supporting arrangement for equipments. Approaches to various levels shall be through structural steel staircases. Open steel staircase from ground to top level with handrails on both sides.

RC foundations for equipments, RC grade slab with RC cable trenches & RC floor drains at ground level.

The foundations of all equipments / structures shall be as per requirement.

d) Control Room

Control Room building shall be designed as RCC framed structure.

Besides housing of control panel/ operator’s consoles, rack area for marshalling cabinets, Engineering console room, process operator’s room, HVAC/ Air handling room(s), UPS and UPS battery room, toilet, rest rooms etc. shall be accommodated in the control room building in general.

Also the instrumentation engineering specification for Control Room should be followed.

e) Pipe-rack

Structural steel pipe-rack with RC foundations having multiple tiers for supporting pipes with suitable platforms for control valve operations and walkway, having HDG grating, MS handrails on both sides with local ladders.

In case, air cooler structures are required, it shall be suitably supporting over pipe-rack. Structural steel platforms be provided with HDG grating, handrails and ladders.
for the entire width of rack below air coolers. Operating platform at top of air coolers with ladder for approach to the same. Open steel staircase for operation & maintenance at required places to be provided from ground to top level with landing at appropriate locations.

Endeavour shall be made to utilize the unoccupied space of the existing pipe rack (if any), after checking the adequacy of the system. Modification/strengthening, if required shall be carried by the contractor.

There should be RC paving below pipe-rack for entire width where crane movement/vehicular traffic is anticipated. There should be PCC paving below pipe-rack located in plants.

f) Pipe Sleepers

The suitable arrangement of concrete supports shall be used to support pipes. The top of concrete of pipe sleepers shall be minimum 300mm above the highest paving points. MS steel insert plates with 20mm bar shall be provided on the sleeper top for pipe fixing depending on requirements. Suitable road crossing arrangement shall be provided for pipe sleepers wherever required.

g) Substation

The Sub-Station building shall be a RCC framed building with Hollow/solid block work side covering and flat roof at top. The ground floor shall be utilized as cable cellar for installation of cable trays. The first floor will have LT/HT panels, UPS & battery room, operator’s room & toilets. The access to first floor shall be provided through two nos. of R.C.C. staircases, each located on either side of building. Transformer bay will be on the rear side of the building, provided with Chain link fencing & gates. Separating walls shall be provided between transformers. The separating walls between sub-station and outdoor transformer bays shall have four hour fire rating.

Also the electrical engineering specification for Substation should be followed

h) Stack Structure and Foundation;

R.C.C. foundation having steel structure/RCC super structure with intermediate platform and accessible cat ladders with cage.
i) **Miscellaneous**

i) Lifting beams / monorails of required capacity for maintenance and / or erection purpose at various locations as per requirements mentioned elsewhere in this document shall be provided. Statutory provisions shall be applicable for all electrically driven monorails.

ii) Miscellaneous local platforms, pipe sleepers, local foundations, local supports etc. as per requirement.
ANNEXURE-V

ES-2516

TECHNICAL SPECIFICATIONS

FOR

CIVIL, STRUCTURAL

AND

OTHER ALLIED WORKS
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<td>17.</td>
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<td>158</td>
</tr>
</tbody>
</table>
1.0 General

1.1 Specifications of materials and workmanship shall be as described in the Central Public Works Department Specifications Vol. I & II (latest) include latest amendments, unless otherwise specified. These CPWD Specifications shall be deemed to form part of this contract. The CONTRACTOR shall procure and maintain copies of the latest CPWD Specifications at site for reference.

1.2 These technical Specifications shall be supplementary to the specifications contained in the CPWD specifications, wherever at variance, these Particular Specifications shall take precedence over the provisions in the CPWD Specifications.

2.0 Reference Codes & Standards

2.1 Wherever reference of IS Specifications/ or IS Codes of Practice are made in the Specifications/ Schedule of Rates or Preambles, reference shall be to the latest edition of IS (Bureau of Indian Standards).

<table>
<thead>
<tr>
<th>IS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS - 383</td>
<td>Coarse &amp; Fine aggregates from natural sources for concrete.</td>
</tr>
<tr>
<td>IS - 427</td>
<td>Distemper, dry, colour as required.</td>
</tr>
<tr>
<td>IS - 432</td>
<td>Mild Steel &amp; Medium tensile steel bars.</td>
</tr>
<tr>
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<td>Code of Practice for Plain and Reinforced Concrete.</td>
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<td>Code of Practice for General Construction in Steel</td>
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<td>IS - 1079</td>
<td>Hot rolled carbon steel sheets &amp; strips</td>
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<td>IS - 1081</td>
<td>Code of practice for fixing and glazing of metal (steel &amp; aluminium) doors, windows and ventilators.</td>
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</table>
IS - 1161 Steel tubes for structural purposes.
IS - 1285 Wrought aluminium & aluminium alloy extruded round tube and hollow sections
IS - 1361 Steel windows for Industrial Buildings.
IS - 1363 Hexagon head bolts, screws & nuts of product grade C : Part - I Hexagon head bolts ( size range M5 to M64)
IS - 1367 Technical supply conditions for threaded steel fasteners
IS - 1786 High strength deformed steel bars & wires for concrete reinforcement.
IS - 2062 Steel for general structural purposes.
IS - 2116 Sand for masonry mortars.
IS - 2212 Code of practice for brickwork.
IS - 2386 Methods of test for aggregates.
IS - 2835 Flat transparent sheet glass
IS - 4021 Timber door, window and ventilator frames
IS - 4923 Hollow Steel sections for structural use.
IS - 4925 Concrete batching and mixing plant.
IS - 5410 Cement Paint
IS - 6477 Dimensions for wrought aluminium & aluminium alloys, extruded hollow sections.
IS - 7318 Fusion welding of steel.
IS - 10262 Recommended guidelines for concrete mix design.
IS - 14871 Products in Fibre Reinforced Cement – Long Corrugated or
Asymmetrical Section Sheets and Fittings for Roofing and Cladding - Specification

3.0 Earthwork

3.1 Excavation

3.1.1 Excavation shall be carried out in soil of any nature and consistency, in the presence of water or in the dry, met on the site to the lines, levels and contours shown on the detailed drawings and CONTRACTOR shall remove all excavated materials to soil heaps on site or transport for use in filling on the site or stack them for reuse as directed by the Engineer-in-Charge.

3.1.2 Surface dressing shall be carried out on the entire area occupied by the buildings including plinth protection as directed without any extra cost. The depths of excavation shown on the drawings are the depths after surface dressing.

3.1.3 The site around all buildings and structures to a width of 3 metres beyond the edge of plinth protection, ramps, steps, etc. shall be dressed and sloped away from the buildings.

3.1.4 Black cotton soil, and other expansive or unsuitable soils excavated shall not be used for filling in foundations, and plinths of buildings or in other structures including manholes, septic tanks etc. and shall be disposed off within the contract area marked on the drawings, as directed, levelled and neatly dressed.

3.1.5 In case of trenches exceeding 2 metres depth or where soil is soft or slushy, the sides of trenches shall be protected by timbering and shoring. The CONTRACTOR shall be responsible to take all necessary steps to prevent the sides of trenches from caving in or collapsing. The extent and type of timbering and shoring shall be as directed by the Engineer-in-Charge.

3.1.6 Where the excavation is to be carried out below the foundation level of adjacent structure, the precautions to be taken such as under pinning, shoring and strutting etc. shall be determined by Engineer-in-Charge. No excavation shall be done unless such precautionary measures are carried out as per directions of Engineer-in-Charge.
3.1.7 Specification for Earth work shall also apply to excavation in rock in general. The excavation in rock shall be done such that extra excavation beyond the required width and depth as shown in drawings is not made. If the excavation done in depth greater than required /ordered. The CONTRACTOR shall fill the extra excavation with concrete of mix 1:5:10 as the foundation concrete at his own cost.

3.1.8 CONTRACTOR shall make all necessary arrangements for dewatering / defiling as required to carry out proper excavation work by bailing or pumping out water, which may accumulate in the excavation pit from any cause/ source whatsoever.

3.1.9 CONTRACTOR shall provide suitable draining arrangements at his own cost to prevent surface water entering the foundation pits from any source.

3.1.10 The CONTRACTOR is forbidden to commence the construction of structures or to carry out concreting before Engineer-in-Charge has inspected, accepted and permitted the excavation bottom.

3.1.11 Excavation in disintegrated rock means rock or Boulders including brickbats which may be quarried or split with crow bars. This will also include laterite and hard conglomerate.

3.1.12 Excavations in hard rock - meant excavation made in hard rock to be done manually, or by blasting using only explosives and / or pneumatic hammers. In case of blasting, control blasting should be adopted depending on site conditions. For using explosives CONTRACTOR shall follow all provisions of Indian Explosives Act / Rules 1983, corrected / revised up to date.

3.1.13 In case of hard rock excavation to be carried out using explosives the, CONTRACTOR shall obtain the written approval in advance.

3.1.14 The measurements for excavations shall be restricted and limited to minimum excavation line as per drawing for payment purposes.

3.1.15 Adequate protective measures shall be taken to see that the excavation does not affect or damage adjoining structures. The CONTRACTOR shall take all measures required for ensuring stability of the excavation and safety of
property and people in the vicinity. The CONTRACTOR shall erect and maintain during progress of work, temporary fences around dangerous excavations at no extra cost.

3.1.16 Excavation in ordinary soil means excavation in ordinary hard soil including stiff heavy clay, hard shale, or compact moorum, or any materials, which can be removed by the ordinary application of spades, shovels, picks and pick axes. This shall also include removal of isolated boulders each having a volume not more than 0.50m³.

3.1.17 Excavation in soft rock includes limestone, sandstone, laterite, hard conglomerates, etc. or other rock which can be quarried or split with crowbars or wedges. This shall also include excavation of tarred pavements, masonry work and rock boulders each having a volume of not more than 0.25m³.

3.1.18 Excavation in hard rock includes any rock bound in ledges or masses in its original form or cement concrete for which in the opinion of the Engineer-in-Charge, requires the use of compressed air, equipment, sledge hammer and blasting or non-explosive materials viz. Acconex manufactured by A.C.C. Ltd. Specifications and instructions for use shall be as per manufacturer.

3.1.19 In case of any difficulty concerning the interpretation of type of soil as mentioned above, the Engineer-in-Charge shall decide whether the excavation in a particular material is in ordinary soil, soft rock or hard rock and his decision in this matter shall be final and binding on the CONTRACTOR and without appeal.

3.2 Filling

3.2.1 Back filling of excavations in trenches, foundations and elsewhere shall consist of one of the following materials approved by Engineer-in-Charge.

- Soil
- Sand
Moorum
Hard-core
Stone/gravel

All back filling material shall be approved by the Engineer-in-Charge.

3.2.2 Soil filling - Soil material shall be free from rubbish, roots, hard lumps and any other foreign organic material. Filling shall be done in regular horizontal layers each not exceeding 20 cm. depth.

3.2.3 Back filling around completed foundations, structures, trenches and in plinth shall be done to the lines and levels shown on the drawings.

3.2.4 Back filling around pipes in the trench shall be done after hydro testing is done.

3.2.5 Back filling around liquid retaining structures shall be done only after leakage testing is completed and approval of Engineer-in-Charge is obtained.

3.2.6 Sand used for filling under foundation concrete, around foundation and in plinth etc. shall be fine/ coarse, strong, clean, free from dust, organic and deleterious matter. The sand filling under foundation shall be rammed with Mech. compactor. Sand material shall be approved by Engineer-in-Charge.

3.2.7 Moorum for filling, where ordered, shall be obtained from approved pits and quarries which contain siliceous material and natural mixture of clay. Moorum shall not contain any admixture of ordinary earth. Size of moorum shall vary from dust to 10 mm.

3.2.8 Hard-core shall be of broken stone of 90 mm to 10 mm size suitable for providing a dense and compact sub grade. Stones shall be sound, free from flakes, dust and other impurities. Hard core filling shall be spread and levelled in layers, 15 cm thick, watered and well compacted with ramming or with mechanical / hand compacts including hand packing wherever required.

3.2.9 If any selected fill material is required to be borrowed, CONTRACTOR shall make arrangements and procure such material from outside borrow pits. The material of source shall be subject to prior approval of Engineer-in-Charge. CONTRACTOR shall make necessary access roads to borrow areas and
maintain the same, if such access roads do not exist, at no extra cost.

3.2.10 Plinth filling shall be carried out with approved material as described earlier, in layers not exceeding 150mm, watered and compacted with mechanical compaction machines. **Engineer-in-Charge** may however permit manual compaction by hand tampers in case he is satisfied that mechanical compaction is not possible. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 24 hours, allowed to dry and then the surface again compacted as specified above to avoid settlements at later stage. The finished level of the filling shall be trimmed to the level specified. Compacted surface shall have at least 95% of laboratory maximum dry density. A minimum of one test per 250 sq. meters of compacted area shall be done.

3.2.11 Whenever the fill material (earth or soil) is purchased, **CONTRACTOR** shall get the approval of Engineer-in-Charge. The CONTRACTOR shall arrange to determine the following properties of the soil and shall get the approval of **Engineer-in-Charge**.

1. Clay content : 15% to 20%
2. Laboratory dry density : Not less than 1600 kg/m³
3. Plasticity Index : Not more than 20

3.2.12 The fill shall be compacted using a vibrating compactor of not less than 1.5 tonne. The fill shall be thoroughly compacted in layers as directed but not more than 200 mm thick. Adequate water shall be used for compaction and the density after compaction shall be not less than maximum dry density obtained in test of IS: 2720 Part-8. Compacted surface shall have at least 90% of laboratory maximum dry density. A minimum of one test per 250 sq. meters of compacted area shall be done.
3.2.13 The Gravel fill shall be non plastic granular material, well graded, strong, with maximum particle size of 50 mm, with not more than 15% passing a 4.75 mm IS sieve, free of all debris, vegetable matter and chemical impurities.

3.2.14 All clods, lumps etc. shall be broken before compaction.

3.2.15 In case of grading/banking successive layers of filling shall not be placed, until the layer below has been thoroughly compacted to satisfy the requirements laid down in this specification.

Prior to rolling, the moisture content of material shall be brought to within +/-2% of the optimum moisture content as described in IS 2720 Part-7. The moisture content shall preferably be on the wet side for potentially expansive soil.

After adjusting the moisture content as described, the layers shall be thoroughly compacted by means approved by Engineer-in-Charge, till the specified maximum laboratory dry density is obtained.

General, fill shall be placed in layers not exceeding 300 mm thickness and shall be thoroughly compacted to achieve a compaction of at least 90% of laboratory maximum dry density up to a depth of 600 mm below finished grade. Final fill of 600 mm thickness shall consist of preferably natural material in, as dug condition except that stones larger than 100 mm shall be removed. It shall be placed in layers not exceeding 150 mm thickness and compacted to achieve of at least 95% of laboratory maximum dry density. Each layer shall be tested in field for density and accepted by Engineer-in-Charge, subject to achieving the required density before laying the next layer. A minimum of one test per 250 sq meters for each layer shall be conducted.

If the layer fails to meet the required density, it shall be reworked or the material shall be replaced and method of construction altered as directed by Engineer-in-Charge to obtain the required density.

The filling shall be finished in conformity with the alignment, levels, cross-section and dimensions as shown in the drawing.
Extra material shall be removed and disposed off as directed by the Engineer-in-Charge.

4.0 Plain and Reinforced Concrete Work

This specifications deals with cement concrete, plain or reinforced, for general use, and covers the requirements for concrete materials, their storage, grading, mix design, strength & quality requirements, pouring at all levels, reinforcements, protection, curing, form work, finishing, painting, admixtures, inserts and other miscellaneous works.

4.1 Materials

4.1.1 Cement: Any of the following cements may be used as required. If soil investigation report recommends any specified type of cement then same shall have precedence.

<table>
<thead>
<tr>
<th>IS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS - 269</td>
<td>Ordinary Portland cement, 33 grade</td>
</tr>
<tr>
<td>IS - 8112</td>
<td>43/53 Grade ordinary Portland cement</td>
</tr>
<tr>
<td>IS - 12269</td>
<td>53 Grade ordinary port land cement</td>
</tr>
</tbody>
</table>

4.1.2 Water: Water used for mixing and curing concrete and mortar shall conform to the requirements as laid down in IS: 456. Sea water shall not be used for concrete work.

4.1.3 Aggregates: Coarse and fine aggregates for cement concrete plain and reinforced shall conform to the requirements of IS 383 and / or IS 515. Before using, the aggregates shall be tested as per IS: 2386.

Coarse aggregate: Coarse aggregate for all cement concrete work shall be broken or crushed hard stone, black trap stone obtained from approved Quarries or gravel.

Sand: Fine aggregate shall consist of natural or crushed sand conforming to BIS 383 and conforming to test as per BIS 2386 parts I to IV.f. Grading of coarse sand shall be within grading zones I, II or III as laid down in IS: 383, table 4. If
required the aggregates (both fine and coarse) shall have to be thoroughly washed and graded as per direction of Engineer-in-Charge.

4.2 Mixing

All cement concrete plain or reinforced shall be machine mixed. Mixing by hand may be employed where quantity of concrete involved is small, with the specific prior permission of the Engineer-in-Charge. 10% extra cement shall be added in case of hand mixing as stipulated in IS-456.

For large and medium project sites the concrete shall be sourced from ready-mixed concrete plants or from on site or off site batching and mixing plants (IS 4926)

4.3 Water Cement Ratio, Laying & Curing

Water Cement Ratio, Laying & Curing shall be done as per IS: 456.

4.4 Grades of Concrete

4.4.1 Grades lower than M 25 shall not be used in reinforced concrete super structures.

4.4.2 A sieve analysis test of aggregates shall be carried out as and when the source of supply is changed without extra charge notwithstanding the mandatory test required to be carried out as per CPWD specification.

4.4.5 All tests in support of mix design shall be maintained as a part of records of the contract. Test cubes for mix design shall be prepared by the CONTRACTOR under his own arrangements and at his costs, but under the supervision of the Engineer-in-Charge.

4.5 Design Mix Concrete

4.5.1 Design mix shall be allowed for major works where it is contemplated to be used by installing weigh batch mixing plant as per IS 4925. At the time of tendering, the CONTRACTOR, after taking into account the type of aggregates, plant and method of laying he intends to use, shall allow in his tender for the design mix i.e., aggregate/cement and water/cement ratios which he considers will achieve
the strength requirements specified, and workability for concrete to be properly finished.

4.5.2 Before commencement of concreting, CONTRACTOR shall carry out preliminary tests for design mix on trial mixes proposed by him in design of mix to satisfy the Engineer-in-Charge that the characteristic strength is obtained. In this regard, CONTRACTOR may consult govt. approved/reputed institute to get design mix done as per IS 10262 at his own cost. The concrete mix to be actually used shall be approved by the Engineer-in-Charge.

4.5.3 Notwithstanding the above, the following shall be the maximum combined weight of coarse and fine aggregate per 50 kg of cement.

<table>
<thead>
<tr>
<th>Grade of Concrete</th>
<th>Maximum weight of fine &amp; coarse aggregates together per 50 kg of cement (for nominal mix only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. M - 10</td>
<td>480 kg</td>
</tr>
<tr>
<td>2. M - 15</td>
<td>350 kg</td>
</tr>
<tr>
<td>3. M - 20</td>
<td>250 kg</td>
</tr>
</tbody>
</table>

4.5.4 The workability of concrete produced shall be adequate, so that the concrete can be properly placed and compacted. The slump shall be as per IS 456.

4.5.5 The minimum consumption of the cement irrespective of design mix shall not be less than the following:

<table>
<thead>
<tr>
<th>Grade of Concrete</th>
<th>Consumption (kg/cu m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 7.5 (1:4:8)</td>
<td>170</td>
</tr>
<tr>
<td>M 10 (1:3:6)</td>
<td>240</td>
</tr>
<tr>
<td>M 15</td>
<td>300</td>
</tr>
<tr>
<td>M 20</td>
<td>330</td>
</tr>
<tr>
<td>M 25</td>
<td>350</td>
</tr>
<tr>
<td>M 30</td>
<td>400</td>
</tr>
</tbody>
</table>
4.6 **Testing of Concrete**

4.6.1 Testing of concrete, sampling and acceptance criteria shall be in accordance with IS 456.

4.7 **Proportioning**
Mixes of cement concrete shall be as ordered. Where the concrete is specified by grade, it shall be prepared by mixing cement, sand and coarse aggregate by weight as per mix design. In case the concrete is specified as volumetric mix, then dry volume batching shall be done, making proper allowances for dampness in aggregates and bulking in sand. Equivalent volume batching for concrete specified by grade may however be allowed by the Engineer-in-Charge at his discretion.

4.8 **Pre Cast Concrete**
The specifications for pre cast concrete will be similar as for the cast in situ concrete. All pre cast work shall be carried out in a yard made for the purpose. This yard shall be dry, properly levelled and having a hard and even surface. If the ground is to be used as a soft former of the units, shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportion) with smooth neat cement finish or a layer of MS sheeting. The casting shall be over suitable vibrating tables or by using form vibrators as per directions of Engineer-in-Charge.

The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 7 (seven) days of curing and can be removed for erection after 28 (Twenty Eight) days of curing. The moulds shall preferably be of steel or of timber lined with G.I .sheet metal. The yard shall preferably be fenced.

Lifting hooks, wherever necessary or as directed by Engineer-in-Charge shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drgs. and shall be burnt off and finished after erection.
Pre cast concrete units, when ready shall be transported to site by suitable means approved by Engineer-in-Charge. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per the instructions of the Engineer-in-Charge. The CONTRACTOR shall render all help with instruments, materials and staff to the Engineer-in-Charge for checking the proper erection of the pre cast units.

After erection and alignment the joints shall be filled with grout or concrete as directed by Engineer-in-Charge. If shuttering has to be used for supporting the pre cast unit they shall not be removed until the joints has attained sufficient strength and in no case before 14 (fourteen) days. The joint between pre cast roof planks shall be pointed with 1:2 (1 cement : 2 sand) mortar.

5.0 STEEL REINFORCEMENT

5.1 Steel reinforcement shall comprise:

1) CRS bars

5.2 All joints in reinforcement shall be lapped adequately to develop the full strength of the reinforcement as per provision of IS: 456 or as per instruction of Engineer-in-Charge.

6.0 Form Work

6.1 The shuttering or form work shall conform to the shape, lines and dimensions as shown on the drawings and be so constructed as to remain sufficiently rigid during placing and compacting of the concrete and shall be sufficiently tight to prevent loss of liquid from the concrete. The surface that becomes exposed on the removal of forms shall be examined by Engineer-in-Charge or his authorized representative before any defects are made good. Work that has sagged or bulged out, or contains honey combing, shall be rejected. All shuttering shall be plywood or steel shuttering.

6.2 The CONTRACTOR shall be responsible for sufficiency and adequacy of all form work. Centering and form work shall be designed & detailed in accordance with IS 14687 and approved by the Engineer-in-Charge, before placing of reinforcement and concreting.
6.3 **Stripping Time**

Forms shall not be struck until the concrete has reached strength at least twice the stress to which the concrete may be subjected at the time of removal of form work. The strength referred to shall be that of concrete using the same cement and aggregates, with the same proportions and cured under conditions of temperature and moisture similar to those existing on the work. Where possible, the form work shall be left longer as it would assist the curing.

Note 1: In normal circumstances and where ordinary Portland Cement is used, forms may generally be removed after the expiry of the following periods:

<table>
<thead>
<tr>
<th></th>
<th>Walls, columns and vertical faces of all structural members</th>
<th>24 to 48 hours as may be decided by the <strong>Engineer-in-Charge</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Slabs (props left under)</td>
<td>3 days</td>
</tr>
<tr>
<td>3</td>
<td>Beam soffits (Props left under)</td>
<td>7 days</td>
</tr>
<tr>
<td>4</td>
<td>Removal of props under slabs</td>
<td></td>
</tr>
<tr>
<td>4.1</td>
<td>Spanning up to 4.5 m</td>
<td>7 days</td>
</tr>
<tr>
<td>4.2</td>
<td>Spanning over 4.5 m</td>
<td>14 days</td>
</tr>
<tr>
<td>5</td>
<td>Removal of props under beams &amp; arches:</td>
<td></td>
</tr>
<tr>
<td>5.1</td>
<td>Spanning up to 6 m</td>
<td>14 days</td>
</tr>
<tr>
<td>5.2</td>
<td>Spanning over 6m</td>
<td>21 days</td>
</tr>
</tbody>
</table>

For other types of cements, the stripping time recommended for ordinary Portland Cement may be suitably modified.

Note 2: The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.
7.0 Cement Concrete Block

Cement concrete block shall be machined made in the proportion of such that mix shall not be leaner than one cement to twelve combined aggregates (by volume) but having minimum strength of 7.5 MPa. Combined aggregate shall be graded as near as possible to IS: 383. The fineness modules of combined aggregate shall be between 3.6 and 4. The concrete block shall be properly cured as per IS-456. The surface of conc. block shall have even face without any honeycomb and free from cracks.

7.7.1 Mortar

Cement and water shall confirm to the requirements laid down for cement concrete work.

7.7.2 Sand for concrete block masonry mortars shall be coarse sand generally conforming to IS: 2116. Maximum quantities of clay, fine dust, shall not be more than 5% by weight. Organic impurities shall not exceed the limits laid down in IS: 2116.

7.7.3 Mix of mortar for building concrete block shall be as specified in the item of work.

7.7.4 Mixing of the mortar shall be done in a mechanical mixer. When quantity involved is small hand mixing may be permitted by Engineer-in-Charge. Any mortar remaining unused for more than 30 minutes after mixing shall be rejected.

7.8 Concrete Block Masonry

The thickness of joints shall be 10 mm +- 3mm. Thickness of joints shall be kept uniform. In case of foundation and manholes etc. joints up to 15 mm may be accepted.

7.9 Half Concrete Block

All courses shall be laid with stretchers. Reinforcement comprising 2 nos. 6 mm dia MS bars shall be provided over the top of the first course and thereafter at every fourth course.
7.10 **Fixtures**

All iron fixtures, pipes spouts, hold fasts of doors and windows which are required to be built into the wall shall be embedded in cement concrete blocks 1:2:4 mix (1 cement :2 coarse sand :4 graded stone aggregate. 20 mm nominal size) of size indicated in the item.

7.11 **Curing**

Concrete block masonry shall be protected from rain by suitable covering when mortar is green. Masonry work shall be kept constantly moist on all faces for a minimum period of seven days.

8.0 **STRUCTURAL STEEL WORK**

This specification covers the technical requirements for the preparation of shop drawings, supply, fabrication, protective coating, painting and erection of all structural steel rolled sections, built up sections, plates and miscellaneous steel required for the completion of the work.

**Steel**

All structural steel used in construction within the purview of this contract shall, comply with one of the following Bureau of Indian Standard Specifications, whichever, is appropriate or as specified.

- IS – 2062 Hot rolled sections and plates
- IS – 1079 Cold formed light gauge sections
- IS – 1161 Tubular sections
- IS – 4923 Hollow sections (rectangular or square)

**Fabrication**

Fabrication of steel structure shall be carried out in conformity with the best modern practices and with due regard to speed with economy in fabrication and erection and shall conform to IS-800. All members shall be so fabricated as to assemble the members accurately on site and erect them in correct positions. Before dispatch to site the components shall be assembled at shop and any defect found rectified. All members shall be free from kink, twist, buckle, bend,
open joints etc. and shall be rectified before erecting in position. Failure in this respect will subject the defective members to rejection.

**Fabrication Drawings:**

Connections, splices and other details shall be suitably designed based on good Engineering practice.

**Electrodes:**

Electrodes used for welding shall comply with IS-814 or IS - 815.

8.1 **MS Black/High Strength Bolts and Nuts**

M.S.Black or high strength bolts, nuts and washers etc. shall be as per IS-800, IS-1363 and IS-1367. Manufacturer's test certificate shall be made available to the Engineer-in-Charge. For bolted joints, shanks and threaded bolts are to be used to ensure that threaded length do not encroach within the thickness of connected members of dimension beyond the following limit:-

1. 1.5 mm for connected members of thickness below 12 mm and
2. 2.5 mm for connected member of thickness 12 mm and above and that adequate shearing and bearing values required as per design are achieved.

Every portion work shall have its erection mark or numbers stencilled on the member for guidance in erection and bear all necessary marks of erections as directed by the Owner / Consultant.

7.13 No part of the work is to be oiled, painted (except contact surfaces ) packed, bundled, crated or dispatched until it has been finally inspected and approved by the Owner / Consultant or his authorized representative. The whole steel work before being dispatched from the Contractor's shop shall be dry and after being thoroughly cleaned from dust, mills scale, rust etc., and shall be given two coats of primer and one coat of final paint as per painting specification attached in this enquiry. Unless otherwise specified, all surfaces inaccessible after welding shall be given two coats of primer and two coats of paints as per painting specification attached in this enquiry.
7.14 The Owner / Consultant or his authorized representative shall have free access at all reasonable time to all places where the work is being carried out, and shall be provided by the Contractor at his own expenses all necessary facilities for inspection during fabrication and erection. The Owner / Consultant or his authorized representative shall be at liberty to reject the work in whole or in part if the workmanship or materials do not conform to the terms of the specifications mentioned herein. The Contractor shall remove, replace or alter any part of the work as ordered by the Owner / Consultant or his authorized representative.

9.0 PAINTING ON STRUCTURAL STEEL

Painting on structural steel shall be as per Painting specification given elsewhere with this Tender. However, the following specification may be considered and used for painting of structural steel work.

9.1 Scope

This specification covers the technical requirements for shop and site application of paint and protective coatings and includes; the surface preparation, priming, application, testing and quality assurance for protective coatings of structural steelwork, plate work, handrails and associated metal surfaces, which will be exposed to atmospheric for industrial plants.

9.2 Definitions

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.S</td>
<td>Carbon steel and low chrome (1-1/4 Cr through 9 Cr) alloys</td>
</tr>
<tr>
<td>S.S</td>
<td>Stainless steel, such as 304, 316, 321, 347,</td>
</tr>
<tr>
<td>Non-ferrous</td>
<td>copper, aluminium and their alloys.</td>
</tr>
<tr>
<td>High Alloy</td>
<td>Monel, Inconel, Incoloy, Alloy 20, Hastelloy, etc.</td>
</tr>
<tr>
<td>DF</td>
<td>Dry Film thickness, the thickness of the dried or curved paint or coating film.</td>
</tr>
</tbody>
</table>

9.3 Safety Regulations
Protective coatings and their application shall comply with all national, state, and local codes and regulations on surface preparation, coating application, storage, handling, safety, and environmental recommendations.

Sand or other materials producing silica dust shall NOT be used for any open-air blasting operations.

9.4 Material Safety Data Sheets

The latest issue of the coating manufacturer’s product datasheet, application instructions, and material safety data Sheets shall be available prior to starting the work and shall be complied with during all preparation and painting / coating operations.

9.5 Materials

All paints and paint materials shall be obtained from the company’s approved manufacturer’s list. All materials shall be supplied in the manufacturer’s containers, durably and legibly marked as follows.

Specification number
Colour reference number
Method of application
Batch number
Date of Manufacture
Shelf life expiry date
Manufacturer’s name or recognised trade mark.

9.6 CODE AND STANDARDS:

Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, the following codes & standards shall be followed. Wherever reference to any code is made, it shall correspond to the latest edition of the code.
9.7 Indian Standards:

IS-5: 1994    Colors for ready mixed paints and enamels.
IS-2379: 1990  Color codes for identification of pipe lines.
IS-2629: 1985  Recommended practice for hot-dip galvanizing on iron and steel.
IS: 110    Specification for Ready Mixed Paint, Brushing, Grey Filler, for Enamels, for Over Primers
IS: 101    Methods of test for ready mixed paints & enamels.

9.8 Other Standards:


(Surface preparations standards for Painting Steel Surface).

This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-in-charge.


9.9 The paint manufacturer's, instructions shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

a. Instructions for storage to avoid exposure as well as extremes of temperature.

b. Surface preparation prior to painting.

c. Mixing and thinning.

d. Application of paints and the recommended limit on time intervals between coats.
9.10 Surface Preparation

9.10.1 Safety

All work in adjacent areas, which may negatively affect the quality of blast cleaning, and/or impose safety hazards, must be completed or stopped before the blasting operation starts.

9.1.2 Pre-Cleaning

Prior to surface preparation all weld spatter shall be removed from the surface, all sharp edges ground down and all surfaces cleaned free of contaminants including chalked paint, dust, grease, oil, chemicals and salt. All shop primed surfaces shall be water washed by means of suitable solvent, by steam cleaning, with an alkaline cleaning agent if necessary or by high-pressure water, to remove contaminants prior to top-coating.

9.1.3 Surface decontamination

Surface decontamination shall be performed prior to paint application when uncoated surface is exposed to a corrosive environment or existing paint work is to be repaired. Existing coatings shall be removed by abrasive blast cleaning, and then high pressure potable water shall be used to clean steel surfaces. Prior to application of coatings, the surface shall be chemically checked for the presence of contaminants. A surface contamination analysis test kit shall be used to measure the levels of chlorides, iron salts and pH in accordance with the kit manufacturer’s recommendations.

Swabs taken from the steel surface, using cotton wool test swabs soaked in distilled water shall not be less than one swab for every 25m² of surface area to be painted.

Maximum allowable contaminant levels and pH range is as follows:

- Sodium chloride, less than 50 microgram / cm²;
- Soluble iron salts, less than 7 microgram / cm²; and
- pH between 6 – 8
If the results of the contamination test fall outside the acceptable limits, then the wash water process shall be repeated over the entire surface to be painted, until the contaminant test is within the specified levels.

9.1.4 Abrasive blasting

All C.S materials shall be abrasive blast cleaned in accordance with relevant IS Codes. To reduce the possibility of contaminating S.S., blasting is not usually specified. However, for coatings which require a blast-cleaned surface for proper adhesion, S.S. may be blast cleaned using clean aluminium oxide or garnet abrasives (Free from any chloride or Iron / Steel contamination). When hand or power tool cleaning is required on S.S., only S.S. wire-brushes (including 410 S.S.) which have not been previously used on C.S. surfaces may be used.

The surface profile of steel surfaces after blasting shall be of preparation grade Sa 2-1/2 of Swedish Standards SIS-05-5900 (Latest Revision) or better according to ISO 8501-1 and shall be measured using the replica tape method or the comparator method.

The roughness (profile) of blast-cleaned surfaces shall be Medium (G) according to ISO 8503-2: 1988 (appendix 1) unless otherwise specified. Medium defines a surface profile with a maximum peak-to-valley height of 60-100 microns, and G indicates that the surface profile is obtained by grit blasting. For the evaluation of surface roughness Comparator G shall be used.

Abrasive blast cleaning shall NOT be performed when the ambient or the substrate temperatures are less than 3 Degree Celsius above the dew point temperature. The relative humidity should preferably be below 50% during cold weather and shall never be higher than 60% in any case.

Abrasive blast cleaning shall be performed with a clean, sharp grade of abrasive. Grain size shall be suitable for producing the specified roughness. Abrasives shall be free from oil, grease, moisture and salts, and shall contain no more than
50ppm chloride. The use of silica sand, copper slag and other potentially silica containing materials shall not be allowed.

The blasting compressor shall be capable of maintaining a minimum air pressure of 7 kPa at the nozzle to obtain the acceptable surface cleanliness and profile.

The blast cleaning air compressor shall be equipped with adequately sized and properly maintained oil and water separators. The air supply shall be checked to ensure no oil and water contamination at the beginning of each work shift.

Blast cleaning abrasive shall be stored in a clean, dry environment at all times. Recycling of used abrasive is prohibited.

After blast cleaning, the surfaces shall be cleaned by washing with clean water (Pressure 7kg/cm² using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matter.

Assessment of the blast cleaned surfaces shall be carried out in accordance with reference code.

Blast cleaned surfaces which show evidence of rust bloom or that have been left uncoated overnight shall be re-cleaned to the specified degree of cleanliness prior to coating.

All grit and dust shall be removed after blasting and before coating application. Removal shall be by a combination of blowing clean with compressed air, followed by a thorough vacuum cleaning with an industrial grade, heavy duty vacuum cleaner.

All cleaned surfaces shall have protection from atmospheric corrosion as per IS8629:1977

9.1.2 **Painting system to be used is indicated below:**

1. **Epoxy Painting:**

   a) Primer P 1-2 coats + finish paint FP1 (2 coats) where P1 is epoxy polyamide cured zinc chromate primer having DFT of 35 micron per coat and FP1 is epoxy polyamide cured finish paint having DFT (Dry Film Thickness) of 35 micron per coat.
Equivalent product chart for approved paint manufactures for primer P1 finish paint FP1 indicated above is enclosed.

2. For PU painting:
   i) P1 – One coat of Ethyl silicate inorganic zinc primer having DFT of 70 microns per coat.
   ii) IP1 – One coat of Epoxy MIO having DFT of 70 microns per coat.
   iii) FP1 - One coat of finish epoxy paint using two pack Polyamide cured epoxy having DFT of 40 microns per coat.
   iv) FP2 - One coat of Aliphatic Acrylic Polyurethane paint having DFT of 40 microns per coat.

Equivalent product chart for approved paint manufactures for P1, IP1, FP1 & FP2 indicated above is enclosed.

9.1.3 All the surfaces must be abrasive blasted and 2 coats of primer plus 1 coat of finish paint applied in the fabrication shop before the same are shifted to site for erection. All the members must be suitably match marked for facilitating proper assembly.

After erection is over all surfaces shall be washed up as follows:

- Washing with clean water (pressure 7 kg/cm²) using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matters.
- Solvent washing if required to remove traces of oil grease etc.

After washing the surface as indicated above, the surfaces shall be suitably touched up to the extent required so that all the damages to the premiered surfaces caused during erection are done up.

b) The surfaces affected by welding and / or gas cutting during erection shall also be suitably touched up. Before touch up is taken up surfaces shall be prepared by mechanical means such as grinding, power brushing etc. to achieve surface finish to ST-3.
c) After touch up work is over as indicated above, all the surfaces shall be given one coat of finish paint to the required specification.

9.1.4 The following points must be observed for painting work:

1. Primer and paint shall be compatible to each other and should be from the same manufacturer.

2. The recommendation of the paint manufacturer regarding mixing, matching and application must be followed meticulously.

3. Technical representative of paint manufacturer should be available at site as and when required by Engineer-in-Charge for their expert advice as well as to ensure that the painting work is executed as per the instruction of paint manufactures.

d) Paints and primers shall be supplied at site in original container with factory seal otherwise such paints and primers shall not be allowed to be used. Mode of application i.e. by spray, brush or roller shall be strictly as per recommendation of paint manufacturer.

e) Painting materials must be used before the expiry date indicated on the containers.

f) Number of coats and DFT per coat must be strictly followed as indicated above. If the desired DFT is not achieved for primer and finish paints in two coats (each), CONTRACTOR shall be required to apply extra coat (s) to achieve the desired DFT without any extra cost to Engineer-in-Charge.

g) Color shade for each coat of primer and finish paint must be different to identify the coats without any ambiguity.

h) Shade for the final finish coat shall be decided by Engineer-in-Charge at site.

i) All painting materials must be accompanied by manufacturers test certificates. However, Engineer-in-Charge has any doubt regarding quality of materials, he shall have the right to direct CONTRACTOR to get the doubtful material tested or and provided (by CONTRACTOR) testing agencies for which no extra payment shall be made to the CONTRACTOR and the charges shall deemed to be covered in the unit rates quoted for fabrication and erection of structural work.
j) DFT for paint shall be measured at least 20 points and mean DFT shall not vary by more than 10% than specified in DFT.

k) Reliable and calibrated Instrument for measurement of DFT shall be arranged and provided by CONTRACTOR at his cost.

l) Thickness of each coat shall also be checked regularly to ensure uniformity in DFT.

9.1.5 Abrasive blasting and painting works, being a specialized job must be carried out through the approved agencies only.

9.1.6 **Equivalent Chart for Various Paint Manufacturers for Epoxy paint**

<table>
<thead>
<tr>
<th>ASIAN</th>
<th>G &amp; N</th>
<th>SHALIMAR</th>
<th>J &amp; N</th>
<th>BERGER</th>
<th>BOMBAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>APCODUR - Epoxy Zinc Chrome Primer</td>
<td>AMERCO AT-71</td>
<td>EPIGARD-4 Zinc Chromate Primer</td>
<td>EPILAC Zinc Chromate Primer</td>
<td>EPILUX-4 Zinc Chromate Primer</td>
</tr>
<tr>
<td>FP1</td>
<td>APCODUR CF 692</td>
<td>NEROLAC TWO COMP EPOXY</td>
<td>EPIGARD XL FINISH</td>
<td>EPILAC 974 ENAMEL</td>
<td>EPILUX-4 ENAMEL</td>
</tr>
</tbody>
</table>

9.1.7 **Equivalent Chart for Various Paint Manufacturers for PU paint**

<table>
<thead>
<tr>
<th>CODE</th>
<th>ITEM</th>
<th>DFT PER COAT (MICRONS)</th>
<th>ASIAN</th>
<th>G &amp; N</th>
<th>SHALIMAR</th>
<th>J &amp; N</th>
<th>BERGER</th>
<th>BOMBAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>ETHYL SLILICATE INORGANIC ZINC PRIMER</td>
<td>70</td>
<td>APCOSIL 601</td>
<td>DYMET - COTE - 9</td>
<td>TUFFKOTE ZILICATE</td>
<td>J&amp;N INORGANIC ZINC SILICATE PRIMER</td>
<td>ZINC ANODE 304</td>
<td>HEAPELS GALVOSIL 1570</td>
</tr>
<tr>
<td>IP1</td>
<td>EPOXY MIO</td>
<td>70</td>
<td>APCODUR</td>
<td>AMER COAT</td>
<td>EPIGUARD HB MIO</td>
<td>EPILAC HB</td>
<td>EPILUX-4</td>
<td>PENTADUR</td>
</tr>
</tbody>
</table>
### 10.0 Steel / Aluminium Doors, Windows and Ventilators

10.1 The Steel doors, windows and ventilators shall be of the size and type as per IS-1361 and IS-1038. Fixing and glazing shall be done as per IS-1081 and as per manufacturer’s instructions. The putty of approved make such as special gold size or equivalent conforming to IS-419 shall be used.

10.2 Aluminium doors, windows and ventilators shall be manufactured from wrought aluminium and aluminium alloy extruded round tube and / or hollow rectangular / square sections conforming to IS: 1285 & IS : 6477 or equivalent as approved by Engineer-in-Charge.

### 11.0 ROOFING & CLADDING

All roof and cladding sheets should be galvalume sheet of 0.5 mm total coated thickness with 550 MPA grade steel confirming to AS 1397 with AZ150 grade coating.

Translucent sheets shall be provided, in non-process areas only, intermittently where day lighting is required.
12.0 FLOORING AND PAVING

12.1 Sub Base of floor

12.1.1 The area to be paved shall be divided into suitable panels. Form work shall be provided. The boarding / battens shall be fixed in position with their toe at proper level, giving slope where required. Alternatively base concrete may be deposited in the whole area at a stretch.

12.1.2 Before placing the base concrete the sub-base shall be properly wetted and rammed. The concrete of the specified mix shall then be deposited between the forms where provided, thoroughly tamped and the surface finished level with the top edge of the forms. The surface of base concrete shall be spreader uniformly. The surface shall be finished rough to provide adequate bond for the topping. Two or three hours after concrete has been laid the surface shall be brushed with wire brush to remove any scum or Latinate and swept clean so that coarse aggregate is exposed.

12.2 Cement Concrete Floor Finishes

12.2.1 The surface of base concrete shall be thoroughly cleaned by scrubbing with coir or steel wire brush. Before laying the topping, the surface shall be soaked with water at least for 12 hours and surplus water mopped up immediately before the topping is laid.

12.2.2 The forms shall be fixed over the base concrete dividing into suitable panels. Where glass dividing strips are provided, thickness of glass dividing strips shall be 4 or as indicated. Before placing the concrete topping, neat cement slurry at the rate of 2 kg/sq.m shall be then thoroughly brushed into the base concrete just ahead of the finish. The topping shall then be laid, thoroughly compacted by using screed board/plate vibrator. The surface floated with a wooden float to a fair and even surface shall be left for some time till moisture disappears from it. Junctions with skirting / dado or wall surfaces shall be rounded off using cement mortar 1:2 curing shall be carried out for a minimum of 7 days.
13.0 PLASTERING

13.1 Sand for plastering shall be 50% fine sand and 50% coarse sand from approved sources.

13.2 Preparation of surface shall be done as per CPWD specifications.

13.3 Cement mortar shall be of the mix as indicated in the items and shall be mixed as specified in the CPWD specifications.

13.4 Joints in walls etc. shall be raked to a depth of 12 mm, brushed clean with wire brushes dusted and thoroughly washed before starting the plaster work.

13.5 The surface shall be thoroughly washed with water cleaned and kept wet to saturation point before plastering is commenced.

13.6 Cement mortar as indicated, shall be firmly applied to the masonry walls in a uniform layer to the thickness specified and will be pressed into the joints. On concrete surfaces rendering shall be dashed to the roughened surface to ensure adequate bond. The surface shall be finished even and smooth. Hectoring wherever required shall be done as per directions of Engineer-in-Charge. Nothing extra shall be paid on this account.

13.7 All plaster work shall be cured for at least 7 days.

13.8 Integral water proofing compound shall be mixed with cement in the proportion recommended by the manufacturer. Care shall be taken to ensure that the waterproofing material gets well and integrally mixed with cement. All other operations are the same as for general plaster work.

13.9 For sand face plaster undercoat of cement plaster 1:4 (1 cement : 4 sand) of thickness not less than 12 mm shall be applied similar to one coat plaster work. Before the under coat hardens the surface shall be scared to provide for the top coat. The top coat also of cement mortar 1:4 shall be applied to a thickness not less than 8 mm and brought to an even surface with a wooden float. The surface shall then be tapped gently with a wooden float lined with cork to retain a coarse surface texture, care being taken that the tapping is even and uniform.
14.0 Exterior Painting or Apex

14.1 Exterior painting shall be Apex.

14.2 Where shown on drawings for external surfaces of sand faced plaster, or any other surface, two coats of cement paint shall be applied of tint and shade as approved by the Engineer-in-Charge.

14.3 The surfaces shall be prepared as specified for white washing. Before applying cement paint the surface shall be thoroughly wetted to control surface suction. The surface shall be moist but not dripping wet, when the paint is applied. Not less than 24 hours shall be allowed between the two coats. In hot weather the first coat shall be slightly moistened before applying the second coat.

14.4 On external plastered surfaces (one coat primer + minimum 3 coat of paints), sand faced or plain plastered and concrete surfaces, apex weather proof paint shall be vigorously scrubbed on to work the paint into the voids and provide a continuous paint film free from pin holes and other openings.

15.0 GLAZING

15.1 Sheet glass glazing of doors, windows etc. shall be of selected quality glass conforming to IS: 2835. Toughened splinter proof industrial safety glass shall confirm to IS: 2553. No cracked chipped or disfigured glass shall be accepted. Glass shall be in one piece for each pan.

15.2 Glazing shall be fixed with timber or steel / aluminium beading as called for. Glass shall be back puttied and fixed with beading for a water tight and rattle free installation. Sizes of timber/ steel / aluminium beading shall be as directed.

16. PROTECTIVE COATING AND LINING SYSTEM

16.1 ACID PROOF TILES:

MATERIAL

1) TILES

These tiles shall be made of clays, feldspar, quartz, talc and vitrified at high temperature in ceramic kilns and kept unglazed so as to prevent from slipperiness. Tiles shall not absorb more than 2% of their own dry weight when soaked in water.
Compression strength: 700 Kg/cm² Min. & Flexural strength: 200 Kg/cm² Min. It shall not lose more than 1.5% of its weight when soaked in acid.

Chemical compositions of tiles:

- $\text{Al}_2\text{O}_3$: 22-24%
- $\text{SiO}_2$: 60-65%
- $\text{Fe}_2\text{O}_3$: 1.0-2.0%
- Alkaline: 10-12%

2) K-BASED SILICATE MORTAR

Acid proof cement KSC is a potassium silicate based corrosion cement. Acid tile linings carried out with KSC cement are not subject to crystal formation in the pores of cement. Besides Bitumastic surface is joint-less, hence there is no danger of Acids percolating through the surface.

Characteristics of K-based Silicate mortar:

- Colour: White
- Density (lbs/Cub. ft.): 130
- Water Absorption: 2-5%
- Tensile Strength (Psi): 400
- Compressive strength (Psi): 2800
- Bond Strength (Psi): 180
- Coefficient of thermal expansion: $6.0 \times 10^{-6}$

3) BITUMASTIC MORTAR

It shall consist of an acid proof inorganic filler and blended bitumen. It shall be trowelled to concrete having total thickness of 10 mm.

Characteristics of Bituminous compounds:

- Density (Kg/m$^3$): 2200
- Water content by mass percent (max): 0.5
4) BITUMINOUS PAINT

This is generally of heavy grade bituminous corrosion resisting paint. 2 coats of the paint shall be given, and drying time between the 2 coats shall not be less than 5 hours. Also, its drying time after second coat shall not be more than 8 hours. Its finish shall be smooth, glossy and elastic.

The primer shall confirm to the following requirements:

- Viscosity by standard tar viscometer, 4mm orifice at 25°C: 4 to 24
- Penetration at 25°C, 100g, 5sec in 1/100 cm: 20 to 50
- Water content percent (max): 0.2

APPLICATION

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>DESCRIPTION</th>
<th>ITEM OR AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Bituminous Paint (Primer)</td>
<td>Concrete surface</td>
</tr>
<tr>
<td>2.</td>
<td>10mm Bitumastic Laying in two layers each shall not be more than 5mm thick</td>
<td>Over Bituminous Paint</td>
</tr>
<tr>
<td>3.</td>
<td>One layer, 5mm Acid, K-based Silicate Type mortar</td>
<td>#</td>
</tr>
<tr>
<td>4.</td>
<td>10 mm thick Acid proof tiling</td>
<td>Over K-based Silicate</td>
</tr>
</tbody>
</table>
# - Tiles should be fixed on bitumastic surface with the help of 5mm K-based silicate mortar.

16.2 **EPOXY COATING**

**A. MATERIAL**

1) **EPOXY COATING**

Characteristics of coated surfaces (after application)

- Compressive strength : min. 90 N/mm²
- Tensile strength : min. 10 N/mm²
- Abrasion resistance : as per Amsler 1.5 mm after 3000 revol.
- Bonding (joining) factor : 1

**APPLICATION:**

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>One coat of two pack interpenetration polymer (Epoxy Phenolic) Thickness 60 micron per coat</td>
<td>Primer coat on Concrete surface</td>
</tr>
<tr>
<td>2.</td>
<td>One coat of two pack interpenetration polymer (Epoxy Phenolic) Thickness 100 micron per coat</td>
<td>Intermediate Coat over Primer Coat</td>
</tr>
<tr>
<td>3.</td>
<td>One coat of two pack interpenetration polymer (Polyurethane) Thickness 50 micron per coat</td>
<td>Final Coat over Intermediate Coat</td>
</tr>
<tr>
<td>4.</td>
<td>Sealing by polysulphide</td>
<td>This will be provided at all joints</td>
</tr>
</tbody>
</table>
16.3 ACID RESISTANT BRICK LINING

A. MATERIAL

These bricks are made of raw materials such as clay or shale of suitable composition with low lime and iron content, feldspar, flint or sand and vitrified at high temperature in ceramic kilns. Bricks shall not absorb more than 2% of their own wt. when soaked in water. Compression strength:  > 700 Kg/cm². Bricks shall not lose more than 1.5% at their own weight when tested for acid resistance.

Chemical compositions of bricks are

a) Al₂O₃  22-24%
b) SiO₂  60-65%
c) Fe₂O₃  1.0-2.0%
d) Alkalies  10-12%

1) K-BASED SILICATE MORTAR

Acid Proof cement KSC is a potassium silicate based corrosion cement. Acid brick linings carried out with KSC cement are not subject to crystal formation in the pores of cement. Besides Bitumastic surface is joint-less, hence there is no danger of Acids percolating through the surface.

Characteristics of K-based Silicate mortar:

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<tr>
<th>Property</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Colour</td>
<td>White</td>
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<tr>
<td>Density (lbs/Cub. ft.)</td>
<td>130</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>2-5 %</td>
</tr>
<tr>
<td>Tensile Strength (Psi)</td>
<td>400</td>
</tr>
<tr>
<td>Compressive strength (Psi)</td>
<td>2800</td>
</tr>
</tbody>
</table>
2) BITUMASTIC MORTAR

It shall consist of an acid proof inorganic filler and blended bitumen. It shall be trowelled to concrete having total thickness of 10 mm.

Characteristics of Bituminous compounds:

- Bond Strength (Psi) : 180
- Coefficient of thermal expansion : $6.0 \times 10^{-6}$

Density (Kg/m$^3$) : 2200

Water content by mass percent (max) : 0.5

Flash point °C, min. : 35

Consistency

c) Before setting (test after 1 hr) min. : 100
d) After setting (test after 24 hr) min. : 80

Mastic shall be heated to 150-300°C and shall be applied in 5 mm layers after surface is cleaned & dried.

3) BITUMINOUS PAINT(PRIMER)

This is generally of heavy grade bituminous corrosion resisting paint. 2 coats of the paint shall be given, and drying time between the 2 coats shall not be less than 5 hours. Also, its drying time after second coat shall not be more than 8 hours. Its finish shall be smooth, glossy and elastic.

The primer shall confirm to the following requirements:

- Viscosity by standard tar viscometer, 4mm orifice at 25°C : 4 to 24
- Penetration at 25°C, 100g, 5sec in 1/100 cm : 20 to 50
- Water content percent (max) : 0.2
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<td>10mm Bitumastic Laying in two layers each shall not be more than 5 mm thick</td>
<td>Over Bituminous Paint</td>
</tr>
<tr>
<td>3.</td>
<td>One layer, 5mm Acid, K-based Silicate Type mortar</td>
<td>#</td>
</tr>
<tr>
<td>4.</td>
<td>One layer, 40mm Acid resistant Brick lining</td>
<td>Over K-based Silicate</td>
</tr>
</tbody>
</table>

#: K-based Silicate mortar should be buttered on all sides of acid-resistant brick except the side facing the surface to be exposed to corrosives

17.0 CULVERT WORK

17.1 Pipe Culverts

17.1.1 Reinforced concrete pipes shall be provided between the drain pits of storm water drains to cross the roads. These pipes shall be non-pressure type conforming to IS: 458 and class as specified in the nomenclature of the item. The pipes shall be laid between the drain pits with a uniform slope and with proper bedding, if required, as per approved drawings. The reinforced concrete pipes shall be manufactured by centrifugal process. All pipes shall be true to shape, perfectly straight, sound and free from cracks. The pipes shall be free from defects resulting from imperfect grading of the aggregate mixing or moulding.

17.1.2 Reinforced concrete pipes shall be laid, jointed and tested as per IS: 783. Pipes shall be laid true to alignment and gradients over cement concrete bed of 1:2:4 mix and / or encased, if required, as per approved drawings or as directed by Engineer-in-Charge. No deviations from the lines, depths of cuttings or gradients shall be permitted without approval in writing by Engineer-in-Charge. The joint between concrete drain pit wall and concrete pipe shall be done properly to make
it water-tight. The pipe joints shall be spigot and socket joint (rigid type) for pipes of 600 mm. diameter and below and collar joint (rigid type) for pipes over 600 mm. diameter. For both types of joints, the annular space shall be filled up with cement and sand mortar 1:2 mix which shall be rammed with caulking tools. After the day's work, any extraneous matter shall be removed from inside of the pipes. Joints shall be cured properly as per IS: 783. Reinforced concrete pipes shall be tested hydraulically as per IS: 783. Refilling of trenches shall not be commenced until the entire length of the pipe has been tested and approved. The excavation of earth in trenches for laying the concrete pipes and refilling shall be done as per IS: 783.

17.2 **Box Culverts**

17.2.1 The box-culverts are to be provided across the roads joining the storm water drains on both sides of the road. These box-culverts shall be of either complete reinforced cement concrete construction or brick masonry and reinforced cement concrete construction as specified in the schedule of items. The box-culvert construction shall be carried out as per the approved drawings.
ANNEXURE-VI

ES-2517

TECHNICAL SPECIFICATION

FOR

WATER SUPPLY, DRAINAGE & SANITATION
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<td>5.0</td>
<td>MANHOLES</td>
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1.0 Scope

1.1 This Specification Covers

The supply, laying and installation of pipes / open surface drains for draining off rain / surface water, fire water, sewage, plant effluent / blow down / floor washings etc., with all fittings and fixtures including jointing.

The supply, laying and installation of pipes for supply of water with all fittings and fixtures including jointing.

The supply and installation of sanitary fixtures like water closets, urinals, wash basins, sinks etc., with all fittings and fixtures.

The supply and installation of toilet accessories like mirrors, shelves, towel rails, liquid soap containers etc., with all fittings and fixtures.

The supply and installation of overhead water tanks with all fittings and fixtures.

The supply and construction of ancillary works like manholes, drop connections, gully chambers, oil traps, soak pits etc., with all fittings and fixtures.

2.0 GENERAL REQUIREMENTS

2.1 The Contractor shall furnish all skilled and unskilled labour, plant, equipments, scaffolding, men, materials, etc., required for complete execution of the work in accordance with the drawings and as described herein and / or as directed by the Engineer.

2.2 The Contractor shall make his own arrangements for locating the coordinates and positions of all works and reduced levels (RL) at these locations based on two reference grid lines and one bench mark which will be furnished by the owner. The Contractor has to provide at site all the required survey instruments etc., to the satisfaction of the Engineer so that the work can be carried out accurately according to the specification and drawing.

2.3 The Contractor shall make good to the satisfaction of the Engineer all cuttings / damages resulting from his operations during the installation.
2.4 Only tentative Plant layout shall be furnished by the Owner. Detailed working drawings showing the layout, installation and other details will be prepared by the Contractor and got approved from the Engineer.

2.5 The Contractor shall dispose of all unserviceable materials at least 50 m away from the plant boundary, unless otherwise directed by the Engineer. All serviceable material shall be stacked within a lead of 500 m as directed by the Engineer.

2.5 In case of any contradiction between the provisions stipulated in this module of technical specification and those of other modules like Excavation and Filling, Cast-in-situ Concrete and Allied works etc., the former shall govern.

All works shall be carried out by qualified / licensed plumbers.

3.0 CODES AND STANDARDS

3.1 All standards, specifications, acts, and Codes of practice referred to herein shall be the latest edition including all applicable official amendments and revisions.

3.2 In case of conflict between this specification and those (IS Standards, codes etc.) Referred to herein (in para 3.3) the former shall prevail.

3.3 Some of the relevant Indian Standards, Acts and Codes referred to herein are given below:

   IS  :  458  :  Precast concrete pipes.
   IS  :  554  :  Dimensions for pipe threads, where pressure tight joints are made on threads.
   IS  :  651  :  Salt glazed stoneware pipes and fittings.
   IS  :  771  :  Glazed fire clay sanitary appliances.
                  (Part-1 to 7)
   IS  :  774  :  Flushing cisterns for water closets and urinals.
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<th>IS</th>
<th>Standard</th>
<th>Description</th>
</tr>
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<td>IS 775</td>
<td>Cast iron brackets and supports for wash basins and sinks.</td>
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<tr>
<td>778</td>
<td>IS 778</td>
<td>Copper alloy gate, globe and check valves for water works purposes.</td>
</tr>
<tr>
<td>781</td>
<td>IS 781</td>
<td>Cast copper alloy screw down bib taps and stop valves for water services.</td>
</tr>
<tr>
<td>782</td>
<td>IS 782</td>
<td>Caulking lead.</td>
</tr>
<tr>
<td>783</td>
<td>IS 783</td>
<td>Code of practice for laying of concrete pipes.</td>
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<tr>
<td>805</td>
<td>IS 805</td>
<td>Code of practice for use of steel in gravity water tanks.</td>
</tr>
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<td>1172</td>
<td>IS 1172</td>
<td>Code of basic requirements for water supply, drainage and sanitation.</td>
</tr>
<tr>
<td>1239</td>
<td>IS 1239</td>
<td>Mild steel tubes, tubular and other wrought steel fittings.</td>
</tr>
<tr>
<td>1536</td>
<td>IS 1536</td>
<td>Centrifugally cast (Spun) iron pressure pipes for water, gas and sewage.</td>
</tr>
<tr>
<td>1703</td>
<td>IS 1703</td>
<td>Copper alloy float valves.</td>
</tr>
<tr>
<td>1726</td>
<td>IS 1726</td>
<td>Cast iron manhole covers and frames.</td>
</tr>
<tr>
<td>1729</td>
<td>IS 1729</td>
<td>Sand cast iron spigot and socket, soil waste and ventilating pipes, fittings and accessories.</td>
</tr>
<tr>
<td>1742</td>
<td>IS 1742</td>
<td>Code of practice for building drainage.</td>
</tr>
<tr>
<td>1795</td>
<td>IS 1795</td>
<td>Pillar taps for water supply purposes.</td>
</tr>
<tr>
<td>2065</td>
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<td>Code of practice for water supply in buildings.</td>
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<tr>
<td>2326</td>
<td>IS 2326</td>
<td>Automatic flushing cisterns for urinals.</td>
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<td>Copper alloy waste fittings for wash basins and sinks.</td>
</tr>
<tr>
<td>IS</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
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IS : 9762 : Polyethylene floats for float valves.
IS : 10446 : Glossary of terms for water supply and sanitation.
IS : 10592 : Industrial emergency showers, eye and face fountains and combination units.
SP : 35 : Hand book on water supply and drainage.

4.0 MATERIAL

4.1 All pipes, fittings, fixtures, appliances and accessories shall conform to the relevant Indian Standards as listed under Clause No. 3.0. These shall be obtained from an approved reputed manufacturer, and shall be approved, the Engineer. Wherever indicated by the Engineer, the Contractor shall submit samples of materials. These may be retained by him for subsequent comparison when bulk supplies are received at site. Ultimate choice of type lies completely with the Engineer.

4.2 The material brought to the site shall be stored in a separate secured enclosure, away from the building materials. Pipe threads, sockets and similar items shall be specially protected till final installation. Brass and other expensive items shall be kept under lock and key. Fragile items shall be checked thoroughly when received at the site and item found damaged shall not be retained at site.

4.3 Chromium plating fittings and appliances shall be of grade-2. (10 micron thickness), conforming to IS: 4827.

4.4 Pipes
Unless otherwise specified, following types of pipes shall be used:

For water supply to buildings, fittings CPVC pipes conforming to IS 15778 shall be used.
For inlet connecting pipes to appliances / fittings, C.P. brass pipe of 15 mm N.B. with union of approved make shall be used. Standard length of 300 mm to 450 mm pipe shall be used to suit the site requirements.

For building sanitary work above ground, UPVC pipes, fittings and accessories conforming to IS: 13592/relevant IS Codes shall be used. Pipes shall be coated with coal-tar by hot dipping process for both inner and outer surfaces.

Glazed stoneware pipes used for sewer and drain shall conform to Grade A of IS: 651. RCC pipe used for sewer and drain shall conform to IS: 458. Class NP2 pipe shall generally be used. However, for road or railway crossing higher class of pipe or concrete encashment shall be provided to take care of higher load.

For drain and sewer line work in bad or unstable ground condition and under building, centrifugally cast (Spun) iron pressure pipes conforming to IS: 1536 shall be used. Class LA pipe with spigot and socket ends shall be used. Pipes shall be coated with coal tar.

PVC rain water pipes shall be used for roof drainage.

4.5 **Above Ground Level**

1) **Galvanised mild steel pipes for water supply**

For work above ground level, the galvanised mild steel pipes and fittings shall run on the surface of the walls, ceiling or in chase as specified or shown on the drawing. The fixing shall be done by means of standard pattern holder bat clamps, provided at no more than 90 cm and keeping the pipes about 1.5 cm clear of the wall. To conceal the pipes, chasing may be adopted or pipes fixed in the ducts or recess etc. Provided there is sufficient space to work on the pipes with the common tools. The pipes shall not ordinarily be buried in walls or solid floors. Under unavoidable situations, pipes may be buried for short stretch after providing adequate protection against damage. Union joints shall be provided for all required locations to facilitate maintenance.

Where directed by the Engineer, a M.S. tube sleeve shall be fixed at a place the pipe is passing through. In case the pipe is embedded, it should be painted with anti-corrosive bitumastic paints conforming to IS: 158. The pipes
shall be oiled and rubbed over the white lead and a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the socket, tee etc., with the pipe wrench. All pipes and fittings shall be properly jointed and made complete water tight. Burr from the joint shall be removed after screwing.

The pipes and fittings shall be checked under working pressure. Any joint found leaking, shall be rectified and all leaking pipes removed and replaced. The pipes and fittings shall be tested to a hydraulic pressure of 6 kg/sq.cm. All pipes used for water supply should be thoroughly and efficiently disinfected before being taken into use. The method of disinfection shall be subject to the approval of the Engineer.

The storage tanks and downtake distribution pipes shall be disinfected together as specified under clause no. 13.2 of IS: 2065-1983, using disinfecting chemical.

2) UPVC pipe above ground for Buildings Sanitary work

For sanitary pipe work above ground for Buildings, 1S:5329 shall be followed for general guidance. Proper ventilation shall be provided in the piping system. The single stack system shall not generally be provided.

Plain pipes shall be secured to the walls at all joints with M.S. holder bat clamps. The clamp shall be made from 1.6 mm thick M.S. sheet of 30 mm width, bent to the required shape and size so as to fit tightly on the socket of the pipe, when tightened with screw bolts. It shall be formed out of two semicircular pieces, hinged with 6 mm dia M.S. pin on one side and provided with flanged ends on the other side with holes to fit in the screw holt and nut, 40 mm long. The clamp shall be provided with a hook made out of 27.5 cm long, 10mm diameter M.S. bar, riveted to the ring at the centre of one semicircular piece. C.I. brackets can also be used. The clamps shall be fixed to the wall by embedding their hooks in cement concrete block 10 x 10 x 10 cm (1:2:4 mix) for which necessary holes shall be made in the wall at proper places. The clamps shall be kept about 25 mm clear of finished face of wall.
All soil pipes shall be carried up above the roof and shall have sand PVC terminal guard. The pipes above parapet shall be secured to the wall by means of clamps.

The pipes shall be fixed perfectly vertical or to the lines as directed. The spigot of the upper pipes shall be properly fitted in the socket of the lower pipe such that here is a uniform annular space for filling with the jointing material. The interior of the socket and exterior of the spigots shall be thoroughly cleaned and dried. The spigot end shall be inserted into the socket right up to the back of the socket and carefully jointed using solvent as per recommendation of manufacturer.

Floor trap shall be ‘Nahni’ or ordinary type and shall conform to IS:1729. The floor shall be suitably lowered to accommodate the trap and the top of the floor shall be properly sloped towards the trap for effective drainage. A chromium plated/galvanised grating shall be provided on the trap. The sunken floor slab shall be filled with light weight materials like cinder mixed with cement. Sunken slab shall be made watertight by means of Sika water proofing compound as recommended by the manufacturer.

**Rain Water Downcomers**

Rain water downcomers and fittings shall be standard PVC rainwater downcomers shall run along and be secured to walls, columns etc. Where desired by the Engineer, these may have to be installed in chases cut out in the structure. All pipes shall be well secured to the walls and supported by adequately strong brackets. The brackets may be wrought iron clevis type, lip-ring type or perforated strap iron type, as approved by the Engineer. Suitable spacer blocks shall be provided against the vertical surface on which the pipe is fixed.

All bends and junctions shall be supplied with water tight cleaning eyes. For improving the aesthetic appearance of the portion of building carrying rain water downcomers, the pipes may have to be concealed by encasing them with brick masonry, concrete, etc.
Galvanized M.S. pipes shall be joined by using standard sockets or by welding. For welding of pipes, IS:11906 shall be followed. After welding, the welded area shall be coated with zinc rich paint after proper cleaning and preparation of the surface. Joints between successive lengths of pipe can be by collars according to provision of IS:1742-1983. All rainwater downcomers shall be provided with roof drain head of the shape and type as shown on the drawing. Unless otherwise specified, dome type drain head shall be used.

3) **Khurra**

The khurra shall be constructed before the brick masonry work in parapet wall is taken up, and it shall be 45x45cm in size, unless otherwise specified and be formed of cement concrete 1 :2:4 (1 cement: 2 sand: 4 graded stone aggregate of 20 mm nominal size).

A PVC sheet 1 mx1 mx400 micron shall be laid under khurra and then cement concrete shall be laid over it to a minimum thickness of 3cm with its top surface lower than the level of adjoining roof surface by not less than 50mm.

The concrete shall be laid to a size greater than the stipulated size of khurra in such a way that the adjoining terracing of brick tile overlaps the concrete on its 3 edges by not less than 7.5 cm. The concrete shall slop e uniformly from the edges to the rainwater outlet. The concrete shall be continued at the same slope through the width of the wall into outlet opening to ensure a water tight joint.

The khurra and the sides of outlet shall then be rendered with 12 mm coat of cement plaster 1:3 (1 cement: 3 sand). This shall be done when the concrete is still green and shall be finished with a floating coat of neat cement. The sides of khurra and the sides of openings shall be well rounded. The size of finished outlet opening shall be 10cm wide by 20cm high or as directed by the Engineer.

Iron grating shall be provided at the outlet to prevent chocking. The grating shall be 20×25cm with an outer frame of 15mm x 3mm MS flat, to which 4
nos. - 10mm dia MS bars shall be welded in vertical direction, keeping an equal clear spacing of 2.5cm.

4) Rainwater Spout

No spout shall be less than 80 mm in diameter. The spacing of spouts shall be arranged to suit the position of openings in the wall.

The spouts shall be of PVC, 60 cm long. These shall be perfectly sound, free from cracks, imperfections of glazing etc. These must be straight, cylindrical and of Standard nominal diameter, length and depth of socket. Full length of pipes shall be used on the work. These must be salt glazed and shall generally conform to IS: 651.

These shall be provided at the mouths of khurras and shall be fixed in cement mortar 1: 4 (1 cement: 4 sand) with the socket embedded in the masonry and the spigot end projecting outside. The masonry around the pipe and socket shall be thoroughly wetted and the hole shall be given a coat of cement mortar around. The pipe shall then be inserted and fixed with a surround of mortar. In case the hole is made much larger than the size of the pipe. Cement concrete 1: 2: 4I (1 cement: .2 sand: 4 graded. stone aggregate of 12.5 mm nominal size) shall be used to fill in the annular space.

The spouts shall slope downward at a slope of 1 in 6. The projection outside the wall shall be uniform and not less than 40 cm. The entrance with the pipe shall be smoothly rounded to meet the internal bore of the pipe to facilitate easy flow. Care shall be taken to ensure that the vertical plane through the centre line of the spouts in a row shall be true to line.

4.6 Below Ground Level:

1) Trenches and other Excavation:

Except as mentioned hereunder, all work for earthwork shall be done as specified in relevant chapter of Excavation and Filling. The trenches shall be so dug that the pipe may be laid to the required alignment and at required depth. The cover shall be measured from top soil or other surface of the ground. Turf, top soil or other surface material shall be set aside, turf being
carefully removed and stacked for use in reinstatement. The bed of the trench, if in soft or made up earth, shall be well watered and rammed before laying the pipes and the depressions, if any, shall be properly filled with earth and consolidated in 20 cm layers.

If the trench is extremely hard or rocky or loose stony soil, the trench shall be excavated at least 150 mm below the trench grade. Rocks, stone or other hard substances from the bottom of the trench shall be removed and the trench brought back to the required grade by filling with selected earth and compacted so as to provide smooth bedding for the pipe. The last 7.5 cm. of excavation shall be trimmed and removed as separate operation immediately prior to the laying of the pipe on their foundations. The width of the trench shall be such as to provide not less than 20 cm clearance on either side of the pipe. Excavation in road shall be so arranged as to cause minimum obstruction to traffic.

2) Laying of Pipes:

In no case, pipes shall be rolled and dropped into the trench. After lowering, the pipes shall be arranged so that the spigot of one pipe is carefully centered into the socket of the next pipe and pushed to the distance that it can go.

The pipe shall be laid with socket facing the direction of flow of water. The connection to an existing sewer shall as far as possible be done at the manhole.

3) Filling of Trench

Filling of the trench shall not be commenced until the length of pipes therein has been tested and passed. Special care shall be taken to pack under and sides of the pipes thoroughly with selected material. At least 300 mm over the pipe shall also be filled with selected earth.

5.0 MANHOLES

5.1 Wherever applicable manhole should be suitably designed & constructed.
ANNEXURE-VII
ES-2509

TECHNICAL SPECIFICATIONS

FOR

BORED CAST-IN-SITU CONCRETE VERTICAL PILES
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1.0 SCOPE

1.1 The specifications cover the installation of bored cast-in-situ reinforced concrete Vertical Piles.

1.2 This specification also covers the technical requirements for load test (Initial and Routine tests) on reinforced concrete single vertical piles of specified diameter to assess their vertical, horizontal and pull-out load carrying capacity.

1.2.1 Load tests on piles shall conform to IS : 2911 (Part – IV).

2.0 GENERAL REQUIREMENTS

2.1 The work shall include mobilisation of all necessary equipment, kentilege, reaction piles, or combination of reaction piles, providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labour, etc. as required carrying out the complete piling work, load tests and submission of records/reports as per schedule.

2.2 The Bidder shall guarantee the “safe load” capacity of piles for various modes i.e., vertical, lateral and pull-out tests for piles installed by him.

2.3 Consequent upon award of work and prior to installation of piles, the Bidder shall submit design of piles in terms of allowable capacity, length, diameter, termination criteria, reinforcement, etc. for OWNER’S/CONSULTANT’S approval. OWNER’S/CONSULTANT’S approval on pile design in no way absolves the Bidder for his responsibility to carry out all the initial (vertical, lateral and pull-out) load test of piles prior to installation of the job piles. The pile capacity to be used in design shall be arrived at from the initial load test of piles.

2.4 The Bidder shall make his own arrangement for locating the co-ordinates and position of piles shown in approved drawings and for determining the Reduced Levels (R.L) of these locations with respect to the single Bench.
Mark indicated by the Engineer-in-Charge. Two established reference lines in mutually perpendicular direction shall be indicated to the Bidder. The Bidder shall provide at site all the required survey instruments to the satisfaction of the Engineering–in–Charge so that the work can be carried out accurately according to specifications and drawings.

2.5 In case of working piles, if the pile is rejected due to any other reasons, the Bidder shall install extra piles at no extra cost to OWNER/CONSULTANT. Further, the extra cost due to the increase in the pile cape size, if any, on account of extra piles shall be borne by the Bidder.

2.6 It is essential that all equipment and instruments are properly calibrated both at commencement and immediately after the tests so that they represent true values. Certificates to this effect from an approved institution shall be furnished to the Engineer-in-Charge. If the Engineer-in-Charge so desires the Bidder shall arrange for having the instruments tested at an approved laboratory at his own cost and the test report shall be submitted to the Engineer-in-Charge. If the Engineer-in-charge desires to witness such tests Bidder shall arrange to conduct the test in his presence.

2.7 The complete jacking system including the hydraulic jack, hydraulic pump and pressure gauge shall be calibrated as unit. The complete unit shall be calibrated over its complete range of travel for increasing and decreasing load same as that of test loads. The calibration certificate shall be submitted to the Engineer-in-Charge.

2.8 The reaction load to be made available for the test shall be at least 25% greater than the maximum jacking force. The reaction system as relevant shall be designed for the total reaction load. All reaction loads shall be stable and balanced during all operations of testing. During testing, stability of reaction system shall be ensured.
2.9 The load applied on the pile shall be measured by a calibrated pressure gauge mounted on the jack.

2.10 The displacement of the pile (in vertical, horizontal and uplift) shall be measured using dial gauges having a least count of 0.01 mm.

2.11 Load test shall be conducted at pile Cut of Level (COL). If the water table is above the COL the test pit shall be kept dry throughout the test period by suitable dewatering methods.

2.11.1 In case initial vertical load test where the water table is higher than the COL BIDDER may use reaction piles for testing purpose in each case. Engineer-in-charge may at his discretion to decide to raise the COL above water table.

2.12 Full details of the equipment proposed to be used and the test set-up with detail sketches shall be submitted to the engineer-in-charge, before making arrangement to carry out the tests, for his approval. Approval of Engineer-in-charge shall also be obtained after the test set up is complete prior to commencement of loading.

2.13 All operations in connection with pile load test shall be carried out in a safe manner so as to prevent the exposure of people to hazard.

2.14 If any test has to be discontinued, which in the opinion of the Engineer interferes with the load test results, and he decides to abandon the test, BIDDER shall install another pile for the purpose and repeat the test after correcting the fault and the cost of all such operations, including the cost of test pile, shall be at the BIDDER’S expenses.

2.15 After completion of piling work Bidder shall submit four copies of the following documents for OWNER’s record and future reference:
a. Initial load test data for all tests done along with the pile data and the analysis of the Initial load test results.

b. Pile data along with concrete mix design detail (Note: pile data shall contain details as per requirement of Annexure – A)

c. Routine load test data for all tests done.

d. A full record giving all details of test in the performa shown in Annexure–B shall be submitted in triplicate to the Engineer-in-charge immediately on completion of each test. The record shall also include the plots of:
   i. Load vs. Settlement
   ii. Time vs. Settlement
   iii. Characteristic of the piles and the interpretation of the pile load test curve as per the criteria for safe loads as mentioned in the specification.

2.16 Before commencement of the work, the bidder shall submit Quality Assurance Plan to OWNER / CONSULTANT for their approval.

3.0 CODES AND STANDARDS.

3.1 All standards and code of practice referred to herein shall be the latest editions including all applicable revisions issued.

3.2 All works shall be carried out as per the relevant latest Indian Standard Codes. In case of conflict between the specification and the IS codes referred to herein, the former shall prevail. Some of the applicable Indian Standards and codes are referred to here below.
IS : 432(part-I&II) Specifications for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.


IS : 1786 Code of practice for twisted steel high strength deformed bars for concrete reinforcement.


SP-34 Handbook on concrete reinforcement and detailing

IS : 5121 Safety code for piling and other deep foundations.

IS: 10262 Recommended guidelines for concrete mix design.


4.0 MATERIALS

4.1 GENERAL

All materials viz. cement, steel, aggregate, water etc., which are to be used for pile construction shall conform to relevant IS codes specifications for properties, storage and handling of common building materials. However, aggregate more than 20 mm shall not be used.
5.0 CONCRETE

5.1 Enclosed Technical Specification for cast-in-situ concrete and allied works along with IS: 2911 (Part-I/Sec.2) – Code of Practice for Design and construction of pile foundations (Bored cast-in-situ piles) shall be applicable to concrete works for piles. Use of plasticizer to control the water-cement ratio shall be permitted on specific approval from Engineer-in-charge.

5.2 GRADE AND MINIMUM CEMENT CONCRETE

5.2.1 Cement concrete of M-30 as per IS 456 shall be used. Cement content shall be as per mix design conforming to IS: 10262. However, the minimum cement content shall be 400 kg per cubic metre of concrete. In case of piles subsequently exposed to free water or in case of piles where concreting is done under water or drilling mud using methods other than the tremie, 10% extra cement over that required for the design grade of concrete at the specified slump shall be used subject to minimum cement specified above.

5.2.2 For the concrete, water, aggregate, cement, reinforcement etc., specification laid down in 9338-PSCV-0000-946 & IS: 456 shall be followed in general. Natural rounded shingle of appropriate size may also be used as coarse aggregate. It helps to give high slump with less water cement ratio.

5.2.3 The concrete for piles in aggressive surroundings due to presence of Sulphates, etc, should have a concrete mix of appropriate type of cement in suitable proportion.

a. If the concentration of sulphates (measured as SO₃) exceeds one percent in soil or 2500 parts per million (ppm) in water, a mix using 400 kg/Cu.m. of super sulphated cement conforming to IS: 6909 or Sulphate resisting Portland Cement conforming to IS : 12330 shall be used. For soils with 0.5 to 1 percent of sulphates or ground water with 1200 to 2500
ppm, the mix should be minimum 400 kg/Cu.m. of super sulphated or sulphate resisting Portland cement. For concentrations less than above, concrete mix with 400 kg/cu. Pozzolona/ blast furnace slag cement shall be used.

b. For bored compaction piles rapid hardening cement shall not be used. To facilitate construction, admixtures for retarding the setting of concrete may be used in consultation with the Engineer-in-charge.

5.3 **SLUMP OF CONCRETE**
The slump of concrete shall vary between 150 mm to 180 mm for concreting in water–free unlined boreholes. For concreting by tremie, a slump of 150 mm to 200 mm shall be used.

6.0 **REINFORCEMENTS**

6.1 Kindly refer clause 5.4 (page 96) for longitudinal and lateral reinforcement in piles. The provision of reinforcement will depend on nature and magnitude of loads, nature of strata and method of installation. It should be adequate for vertical load, lateral load and moments, acting individually or in combination.

6.2 The minimum area of longitudinal reinforcement shall be 0.4 percent of the sectional area calculated on the basis of outside area of casing or pile shaft where casing Is not used, whichever is more. The minimum number of longitudinal reinforcement shall be 6 (Six) and its minimum diameter shall be 12 mm. The stipulated minimum reinforcement shall be provided for full length of pile. Adequate reinforcement shall be provided to take full uplift loads.

6.3 Longitudinal reinforcement shall project 50 times its diameter above cut off level unless otherwise indicated.
6.4 The minimum diameter of the links or spirals bar shall be 8.0 mm and the spacing of the links or spiral shall not be more than 150 mm. The laterals shall be tied to the longitudinal reinforcement to maintain its shape and spacing.

6.5 Reinforcement cage shall be sufficiently rigid to withstand handling and installation without any deformation and damage. As far as possible number of joints (laps) in longitudinal reinforcement shall be minimum. In case the reinforcement cage is made up of more than one segment, these shall preferably be assembled before lowering into casing tube / pile bore by providing necessary laps as per IS : 456.

6.6 Laps shall be staggered as far as practicable and not more than 50% bars shall be lapped at a particular section. Lap joints shall be staggered by at least 1.3 times the lapped length (centre to centre).

6.7 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers cast specifically for the purpose.

6.8 Minimum clear cover to all main reinforcements in piles shall not less than 50 mm unless otherwise specified.

7.0 PILE INSTALLATION

Installation of piles shall be carried out as per pile layout drawings, installation criteria and the direction of the Engineer-in-charge.

7.1 EQUIPMENT AND ACCESSORIES

7.1.1 The equipment and accessories for installation of bored cast-in-situ piles shall be selected giving due consideration to the sub-soil conditions, ground water conditions, and the nature of the excavation.
condition and the method of casting etc. These shall be of standard type and shall have the approval of the Engineer-in-charge.

7.1.2 List of details of equipment and accessories proposed to be used for the job shall be submitted along with the bid.

7.1.3 The capacity of the rig shall be adequate so as to reach the specified founding level.

7.2 CONTROL OF POSITION AND ALIGNMENT

7.2.1 Piles shall be installed as accurately vertical as possible at the correct location and truly vertical. Great care shall be exercised of a single pile or piles in two piles groups under a column. The permissible limits for deviation with respect to position and alignment (inclination) shall conform to IS : 2911 (Part-I/ sec-2 ), which is reproduced below for ready reference:

a. The maximum deviation of vertical piles shall not exceed 1.5% in alignment.

b. Piles shall not deviate more than 75 mm (their designed position at cut off level). In case of single pile, this tolerance should not exceed 50 mm. In case of piles deviating beyond these limits, the pile shall be replaced or supplemented by one or more additional piles without any extra cost to NER/CONSULTANT.

7.3 BORING

7.3.1 Boring operation shall be done by rotary or percussion type drilling rigs using direct, reverse mud circulation (DMC or RMC) method or grab method. In soft clays and loose sand, bailer method, if used, shall be used with caution to
avoid the effect of suction. Boring operations by any of the above method shall be done using drilling mud.

7.3.2 Bidder shall satisfy himself about the suitability of the method to be adopted for site. If DMC or RMC is used bentonite slurry shall be pumped through drill rods by means of high pressure pumps. The cutting tool shall have suitable ports for the bentonite slurry to flow out at high pressure. If on mobilisation, Bidder fails to make a proper bore for any reason, the bidder has to switch over to other boring methods as approved by the Engineer-In-charge at no extra cost to OWNER.

7.3.3 Working level shall be above the cut of level. After the initial boring of about 1.0 to 2.0 m temporary guide casing shall be lowered in the pile bore. The diameter of guide shall be of such diameter to give the necessary finished diameter of concrete pile. The centre line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum 1.0 m length. Additional length of casing may be used depending on the condition of strata, ground water level etc.

7.3.4 Use of drilling mud (bentonite suspension/slurry) for stabilising the sides of the pile bore is necessary wherever is likely to collapse in the pile bore. Drilling mud to be used shall meet the following requirement:

7.3.4.1 Liquid limit of bentonite when tested in accordance with IS : 2720 (Part-V) shall more than 300 percent and less than 450 percent.

7.3.4.2 Sand content of the bentonite powder shall not be greater than 7 percent.

7.3.4.3 Bentonite solution should be made by mixing it with fresh water using pump for circulation. The density of the freshly prepared bentonite suspension shall be between 1.034 and 1.100 gm/ml depending on the pile dimensions and type of soil in which the pile is to be cast. However, the density of bentonite
suspension after mixing with deleterious materials in the pile bore may be up to 1.25 gm/ml.

7.3.4.4 The marsh viscosity when tested by a Marsh cone shall be between 30 to 60 seconds.

7.3.4.5 The differential free swell shall be more than 540 percent.

7.3.4.6 The pH value of the bentonite suspension shall be between 9 and 11.5.

7.3.5 The bentonite slurry and the cuttings, which are carried to the surface by rising flow of slurry shall pass through settling tanks of adequate size to remove the sand and soils from the slurry, before the slurry is recirculated to the boring. The bentonite slurry mixing and recirculation plant shall be suitably designed and installed.

7.3.6 The bentonite slurry shall be maintained at 1.5 m above the ground water level during the boring operations and till the pile is concreted. When DMC and RMC method is used the bentonite slurry shall be under constant circulation still start of concreting.

7.3.7 The size of cutting tools shall be not less than the diameter of the pile by more than 75 mm. However, the pile bore shall be of the specified size.

7.3.8 Socketing shall be done as per Geo-technical Report/ pile design requirement point of view wherever required.

7.4 CHISELLING

7.4.1 Chiselling may be restored with the permission of the Engineer-in-charge below the socketing horizon. The chiselling tool or bit shall be of adequate size and weight so as to reach the desired depth.

7.5 CLEANING OF PILE BORE

7.5.1 After completion of the pile bore up to the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge / bored materials, debris of rock/ boulder etc. Necessary checks shall be made for pile bore as described in the subsequent clauses to confirm thorough cleaning of the pile bore.
7.5.2 Pile shall be cleaned by fresh drilling mud through tremie pipe before start of concreting and after placing reinforcement.

7.5.3 Pile bore spoil along with the used drilling mud shall be disposed off from site as directed by the Engineer-in-charge.

7.6 ADJACENT STRUCTURES

7.6.1 When working near existing structures care shall be taken to avoid any damage to such structures.

7.7 CONCRETING

7.7.1 Concreting shall not be done until the Engineer-in-charge is satisfied that the pile termination level is reached and the pile bore is cleaned properly and thoroughly.

7.7.2 The time interval between the completion of boring and placing of concreting shall not exceed 6 hours. In case the time interval exceeds 6 hours the pile bore shall be abandoned. However, the Engineer-in-charge may allow concreting provided the Bidder extends the pile bore by 0.5 m beyond the proposed depth, and clean the pile-bore. The entire cost of all operation and materials for this extra length shall be borne by the Bidder.

7.7.3 Pile bore bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before and after placing the reinforcement cage.

7.7.4 Proper placement of the reinforcement cage to its full length shall be ensured before concreting.

7.7.5 Concreting shall be done by tremie method, the operation of tremie concreting shall be governed by IS : 2911 ( Part-I/Section-2 ). Drilling mud shall be maintained sufficiently above the ground water level.

7.7.6 Concreting operation shall not proceed if the contaminated drilling mud at the bottom of the pile bore posses density more than 1.25 Te/Cu.M. or sand content more than 7%. The drilling mud bore sample shall be collected from the bottom of the pile bores as mentioned in subsequent clause.
7.7.7 Consistency of the drilling mud suspension shall be controlled throughout concreting operations in order to keep the bore stabilised as well as to prevent concrete getting mixed with the thicker suspension of the mud.

7.7.8 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.

7.7.9 The temporary guide casing shall be withdrawn cautiously after concreting is done upto the required level. While withdrawing the casing concrete shall not be disturbed.

7.8 **CUT OFF LEVEL (COL)**

7.8.1 Cut off level of piles shall be as indicated in drawings released for construction or as directed by Engineer-in-charge.

7.8.2 The top of concrete in pile shall be brought above the COL to remove all laitance and weak concrete and to ensure good concrete at COL for proper embedment in to pile cap.

7.8.3 When the pile cut off level is less than 1.0 metre below the working level, concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection. In case of COL of pile is more than 1.0 metre below working level then concrete shall be cast to a minimum of one metre above COL.

7.8.4 In the circumstance where COL is below ground water table, the need to maintain a pressure on the unset concrete equal to or greater than water pressure shall be observed and accordingly length of extra concrete above COL shall be determined by the Bidder with prior approval of Engineer-in-charge.

7.9 **SEQUENCE OF PILING**

7.9.1 Each pile shall be identified with a reference number.

7.9.2 The convenience of installation may be taken into account while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed piles.
7.10.0 BUILDING UP OF PILES

7.10.1 If any pile, already cast as per construction drawing, requires any extra casting due to any change in cut off level or cast pile top level is less than the specified level or any other reason, then the pile shall be building up by using M-20 grade concrete with minimum 400 kg/Cu.m. of cement ensuring proper continuity with the existing concrete and to the satisfaction of the Engineer-in-charge. Necessary reinforcement as per design requirement and suitable shuttering shall be provided before casting the concrete. Surrounding soil shall also be built up to the required level by proper compaction to ensure lateral capacity of the pile.

7.11 BREAKING OFF OF PILES

7.11.1 If any pile already cast requires breaking due to lowering in cut off or for any other reason, then the same shall be carried out, not before seven days of casting of, without affecting quality of existing pile such as loosening, cracking etc., to the satisfaction of the Engineer-in-charge.

7.12 PREPARATION OF PILE HEAD

7.12.1 The soil surrounding the piles shall be excavated upto the bottom of the lean concrete below the pile cap with provision for working space sufficient enough to place shuttering, reinforcement, concreting and any other related operations.

7.12.2 The exposed part of the concrete above COL shall be removed/ chipped off and made square at COL not before seven days of casting of piles.

7.12.3 The projected reinforcement above COL shall be cleaned and bent to the required shape and level to be anchored into the pile cap.

7.12.4 The pile top shall be embedded into the pile cap by 50 mm or clear cover to the reinforcement, whichever is high.

7.12.5 At loose material on the top of pile head after chipping to the desired level shall be removed and disposed off upto a lead of 2 Km. as directed by Engineer-in-charge.
7.13 REJECTION AND REPLACEMENT OF DEFECTIVE PILES

7.13.1 The Engineer-in-charge reserves the right to reject any pile which in his opinion is defective on account of load capacity, structural integrity, position, alignment, concrete quality etc. Piles that are defective shall be pulled out or left in places as judged convenient by Engineer-in-charge, without affecting the performance of adjacent piles. The Bidder shall install additional piles to substitute the defective piles as per the directions of Engineer-in-charge at no extra cost to OWNER/ CONSULTANT.

7.14 RECORDING OF PILING DATA

7.14.1 The Bidder shall record all the information during installation of piles. Typical data sheet for recording pile data shall be as indicated in Annexure - A. enclosed and the pile load test data shall also be recorded as per the detailed indicated in Annexure-B enclosed. On completion of each pile installation, pile record in triplicate shall be submitted to Engineer-in-charge within two days of completion of concreting of the pile.

8.0 SAMPLING, TESTING AND QUALITY ASSURANCE

8.1 Facilities required for sampling and testing materials, concrete, etc. in field and in laboratories shall be provided by the Bidder. The Bidder shall carry out all sampling and testing in accordance with the relevant Indian Standards and this specification. Where no specific testing procedure is mentioned the testing should be carried out as per the prevalent accepted engineering practice to the direction of Engineer-in-charge. Test shall be done in presence of Engineer of Engineer-in-charge or his authorised representative. In case the Engineer-in-charge requires additional tests, the Bidder shall arrange to get these tests done and submit to him the test results in triplicate within three days after completion of any test.

8.2 RECORDS

The Bidder shall maintain records of all inspection and testing which shall be made available to the Engineer-in-charge. The Engineer-in-charge at his
discretion may waive some of the stipulations for small and unimportant concreting operations and other works.

**UNSUITABLE MATERIALS**

Materials found unsuitable for acceptance shall be removed and replaced by the Bidder. The work shall be done as per specification requirements and to the satisfaction of the Engineer-in-charge at no extra cost to OWNER.

### 8.3 QUALITY ASSURANCE PROGRAMME

#### 8.3.1

The Bidder shall submit and finalise a detailed Field Quality Assurance Programme within 30 days from the date of award of contract according to the requirements of this specification. This shall include setting up a testing laboratory, arrangement of testing apparatus/equipment, deployment of qualified/experienced manpower, preparation of field quality plan, etc. On finalised field quality plan, OWNER/CONSULTANT shall identify, customer hold points, beyond which the work shall not proceed without written approval from the Engineer-in-charge. The testing apparatus/equipment installed in the field laboratory shall be calibrated/corrected by the qualified persons as frequently as possible to give accurate testing results.

#### 8.3.2

Frequency of sampling and testing, etc. and acceptance criteria are given in Table–1. The testing shall be done at field laboratory or any other laboratory approved by the Engineer-in-charge. However, the testing frequencies set forth are the desirable minimum and Engineer-in-charge shall have the full authority to call for tests as he may deem necessary to satisfy himself that the materials and works comply with the appropriate specifications. The materials shall be tested to all the specified requirements as per relevant IS codes before acceptance at manufacturers premises or at independent Government laboratory. Tests indicated in the Table–1 are for cross checking at site the conformity of the materials to some of the specifications.

### 8.4 TESTING OF CONCRETE

#### 8.4.1

a. Concrete and other materials shall be tested for quality and strength and other properties as per relevant IS codes.
b. One sample consisting of six test cubes shall be made from the concrete used in each test pile, 3 to be tested after 7 days and 3 after 28 days.

8.4.2 For working piles testing should be done as per IS specifications.

8.4.3 In preparation of test cubes/ specimens vibrators shall not be used.

8.4.4 Concrete shall be tested for slump at every one hour interval.

8.4.5 Other materials like aggregate, reinforcement, etc. shall be tested as per relevant IS codes.

8.5 TESTING FOR POSITION AND ALIGNMENT

8.5.1 Each pile shall be checked for its position with respect to specified location. Each pile bore shall be checked for its alignment.

8.5.2 Permissible limits for deviations shall be as specified elsewhere in this section of specification.

8.7 PROPERTIES OF DRILLING MUD

8.7.1 Properties of drilling mud shall be checked as per requirements specified in clause No. 7.03.4 of this specification. Prior to use in piling work and thereafter minimum once in a week or as found necessary by Engineer-in-charge one sample consists of 3 specimens shall be tested.

8.7.2 Density and sand content of the drilling mud shall be checked at least in each pile for the first 10 piles before concreting. In case of satisfactory results the frequency of sampling shall not less than one in 25 piles.

8.8 CHECK FOR PILE BORE

8.8.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by Engineer-in-charge to ensure that it is free from pile bore spoil/ debris and any other loose material before concreting. Concreting shall be done only after the approval of the Engineer-in-charge.

8.8.2 For sampling of drilling mud from the pile bore the following method or any suitable method shall be adopted.
8.8.2.1 A solid cone shall be lowered by a string to bottom of pile-bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

9.0 LOAD TEST ON PILES

9.1 TYPE OF TESTS

9.1.1 BIDDER shall carry out two categories of load tests i.e. Initial Load and Routine Load Tests in accordance with IS: 2911 (Part-IV).

9.1.2 Initial load test shall be conducted to assess the safe load carrying capacity of pile before start of installation of working piles. This shall include the following type of tests.

a. Cyclic compression load test to assess safe vertical load capacity.

b. Lateral load test to assess safe horizontal load capacity.

c. Tension load test to assess safe pull out load capacity.

The above tests shall be performed in accordance with IS: 2911 (Part-IV)

9.1.3 The minimum number of Initial Load Test for each diameter of pile proposed shall be as under.


b. Lateral : 2 Nos.

9.1.4 Routine load tests of piles as per IS: 2911 (Part-IV) shall be conducted to verify the load capacity of working piles. This shall include the following types:

a. Direct compression load tests for vertical load capacity.

b. Lateral load test for horizontal load capacity.

9.1.5 The minimum number of routine load test for each diameter and type shall be 1.5 percent of the total number of working piles or minimum 2 no.’s of
piles whichever is higher. The number of tests may be increased up to 2 percent as decided by the Engineer-in-charge in a particular case depending upon the nature, type of structure and strata condition.

9.2 TEST OF PILE

9.2.1 The test piles for routine load test shall be identified by the Engineer-in-charge

9.2.2 A minimum time period of four weeks shall be allowed between the time of pile casting and testing. Test pile head shall be prepared for testing purposes only one week after casting the pile.

9.2.3 The test pile shall be cut off at the proper level and provided with a proper cap so as provide a plane bearing surface for the test plate and for proper arrangements for seating of the jack and dial gauges.

9.3 VERTICAL LOAD TEST

9.3.1 EQUIPMENT AND TEST SET-UP

I. A steel plate of sufficient thickness not less than 50 mm shall be centred on the pile head to prevent it from crushing under applied load. The size of plate shall not be less than the pile size nor less than the area covered the base of the hydraulic jack(s).

II. The datum bars shall be supported on the immovable supports preferably of concrete pillars or steel sections placed sufficiently far away from the test pile. The distance shall not be less than 3 times the diameter of test pile and in no case less than 2 meter from the edge of test pile. These supports shall be placed at a sufficient depth below ground to be unaffected by ground movements.

9.3.2 LOADING SYSTEM

The test load on the pile shall be applied in one of the following way as approved by Engineer-in-charge.

a. By means of hydraulic jack(s) which obtain reaction from kentledge heavier than the required test load. While using this method care shall
be taken to ensure that the centre of gravity of kentledge is on the axis of the file. The load applied by the jack shall also be coaxial with the pile. The nearest edge of the crib supporting the kentledge stack shall not be closer than 1.5 m to the edge of the test pile.

b. By means of hydraulic jack(s) which obtained reaction from anchor piles and/or suitable loading frame. While using this method all anchor piles shall be at a centre to centre distance of at least three times the test pile shaft diameter from the test pile and in no case less than 2 meter. Care shall be exercised to ensure that the datum bar supports are not affected by heaving up the soil.

c. By means of hydraulic jack(s) which obtain reaction from suitable rock anchors. When this method is adopted the anchor transferring the load to the ground shall not be closer than two times the test pile shaft diameter to the test pile and in no case less than 1.5 m.

d. By means of combination of kentledge anchor pile and rock anchors.

9.3.3 MEASURING SYSTEM

Settlement of the pile shall be recorded by four dial gauges placed at diametrically opposite locations and suspended from the datum bar around the pile.

9.3.4 TEST PROCEDURES

The test shall be carried out by Direct Loading Method in successive increments for routine load test and by the Cyclic Loading Method for initial load test as detailed below and as directed by Engineering-in-charge.

9.3.4.1 DIRECT LOADING METHOD

The test shall be carried out as per the procedure out lined below:

a. The load shall be applied to the pile top in increments (step) of about 20% of the rated capacity of the pile or as directed by Engineer-in-charge. Each increment of load shall be applied as smoothly and expeditiously as possible. Settlement regarding shall be taken before and
immediately after the application of next increment and at 15, 30, minutes and thereafter at every half an hour until application of the next load increment.

b. Each stage of loading shall be maintained till the rate of movement of the pile top is not more than 0.2 mm/hour. Or until two hours have elapsed whichever is earlier.

c. The rate of movement of pile shall not be permitted to be extrapolated from period of test less than one hour.

d. Loading on pile shall be continued till one of the following takes place:

   - In case of Initial load test applied load reaches three times the assumed safe load or settlement of pile exceeds a value of 10% of bulb diameter in case of under-reamed piles.

   - In case of Routine load test, applied load reaches one and half time the safe load or maximum settlement of test loading in position attains 12 mm.

e. Where yielding of soil does not occur, the full test load shall be maintained on the pile head for a minimum period of 24 hours. After the last increment of load and settlement shall be recorded of 6 hours interval during this period.

f. Unloading shall be carried out in the same steps as loading. A minimum period of 30 minutes shall be allowed to elapse between two successive stages of load decrement. The final rebound shall be recorded 6 hours after the entire test load has been released.

9.3.4.2 CYCLIC LOAD TEST

The test shall be carried out to find out separately skin friction and point bearing capacity of single pile. However, this test is not applicable for under-reamed piles. The test procedure shall be given below:

a. In general this test shall be conducted on similar lines as mentioned in Direct Loading Method. In addition, alternate loading and unloading up
to zero load shall be done in steps at each stage of loading. The load increment/decrement for each steps shall be 20% of the rated capacity. The reading of all the dial gauges shall be recorded at the end of each step and the total and net settlement for each stage shall be calculated.

b. For each stage, the loading of each step shall be maintained for 15 minutes before reaching the maximum load. The maximum load for each stage shall be maintained on the pile head for 24 hours.

c. Each step of unloading shall be maintained for 15 minutes and the subsequent rebound in the pile shall be measured accurately.

d. A period of 15 minutes shall be allowed to pass the successive unloading and loading operations.

e. To find out separately skin friction and point bearing capacity of pile the procedure as given in Appendix-A of IS: 2911 (pat-IV) shall be followed.

9.3.5 ASSESSMENT OF SAFE LOAD

9.3.5.1 The safe vertical load on single pile from the load test shall be the least of the following:

a. 2/3 of the load at which the total settlement attains a value of 12 mm unless otherwise specified in tender documents.

b. 50% of the final load at which the total settlement equal 10% of the pile diameter in case of uniform diameter.

9.4 HORIZONTAL LOAD TEST

9.4.4 EQUIPMENT AND TEST SET–UP

a. The test plate shall be set in high strength grout to provide full bearing against the projected areas of the pile. The size of the test plate shall be adequate to accommodate the spherical bearing and transfer the load to the pile.

b. Sufficient clearance shall be allowed between the test pile and the datum bar for the anticipated lateral movement of the pile when
datum bar (for fixing the dial gauge) is located on the opposite side to the point load of application.

9.4.5 LOADING SYSTEM

a. Loading shall be applied by a hydraulic jack of adequate capacity equipped with spherical bearing at the top of ram and bearing plate at the bottom side abutting the pile horizontally and reacting against a suitable system.

b. The reaction may be provided by the wall of the excavated pit when the test is being conducted below ground level or by a neighbouring pile in which case thrust pieces shall be inserted on their end of the jack to make up the gap as approved by Engineering-in-charge.

c. Load shall be applied on the pile at or approximately at cut of level (COL).

9.4.6 MEASURING SYSTEM

9.4.6.1 The deflection shall be measured at a point diametrically opposite to the point of load application. In case such a measurement is not possible the deflection shall be recorded using at least 2 dial gauges keep at a spacing of 30 cm at a suitable height and the displacement interpolated at load point from similar triangles.

9.4.6.2 Deflection of the pile at the level of load application shall be measured by dial gauge fixed to datum bar. The datum bar shall rest on immovable supports as described elsewhere in this specification.

9.4.4 TEST PROCEDURE

9.4.4.1 The test shall be similar to that of vertical load test.

9.4.4.2 Loading on the pile shall be continued till one of the following takes place:
a. In case of initial load test applied load reaches thrice the assumed safe lateral load capacity of deflection pile at the loading point exceeds.

b. In case of routine Load test, applied load reaches one and half times the assumed safe load capacity or a deflection of the loading point exceed 5 mm.

9.4.5 ASSESSMENT OF SAFE LOAD

9.4.5.1 The safe lateral load of single pile shall be the least of the following:

a. 50% of the load for which the total deflection is 12 mm.

b. Load corresponding to 5 mm total deflection.

However, for routine test(s) above is not applicable.

Note: The deflection of the pile is at the cut of level of pile.

9.5 PULL OUT TEST

9.5.1 EQUIPMENT AND TEST SET-UP

Uplift force may be applied by means of hydraulic jack(s) using suitable pullout set up as approved by Engineering-in-charge.

9.5.2 LOADING SYSTEM

a. Load shall be applied along the longitudinal axis of the pile using an approved reaction system. Uplift forces on the pile may be applied directly to the test pile or through a lever system.

b. The reaction may be provided by neighbouring piles or blocks constructed for this purpose.

c. The reaction supports/blocks/piles shall be at least 2.5 times the test pile diameter.
9.5.3 MEASURING SYSTEM

Displacement of the pile shall be recorded using two dial gauges placed at diametrically opposite locations and suspended from the datum bar around the pile. Datum bar shall be provided with immovable supports as described elsewhere in this specification.

9.5.4 TEST PROCEDURE

9.5.4.1 The test procedure shall be similar to that for vertical load test.

9.5.4.2 The loading on the pile shall be continued till one of the following takes place.

   a. The loading on the pile top equal three times the estimated safe load.
   b. The load displacement curve shows a clear break (downward trend).

9.5.5 ASSESSMENT OF SAFE LOAD

9.5.5.1 The safe load of the pile shall be the least of the following:

   a. Two third of the load at which the total displacement is 12 mm.
   b. 50% of the load at which the load displacement curves shows a clear break (downward trend).

   c.

10 RECORDING OF DATA AND PRESENTATION

10.1 The pile test data essentially concerns three variables, namely load, displacement and time. These are to be recorded sequentially for the tests under consideration and shall be recorded in a suitable tabular form along with the information about the pile as per Annexure–A, Annexure–B and Table-1

10.2 The data may be suitably presented by curves drawn between the variables and safe loads shown on the graphs. Load displacement curve should be an essential part of presentation.
### ANNEXURE – A

#### PILE DATA

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reference No: Location (Co-ordinates): Area:</td>
</tr>
<tr>
<td>2</td>
<td>Sequence of piling:</td>
</tr>
<tr>
<td>3</td>
<td>Pile diameter and type:</td>
</tr>
<tr>
<td>4</td>
<td>Working Level (Platform level):</td>
</tr>
<tr>
<td>5</td>
<td>Cut Off level (COL):</td>
</tr>
<tr>
<td>6</td>
<td>Actual length below COL:</td>
</tr>
<tr>
<td>7</td>
<td>Pile termination level:</td>
</tr>
<tr>
<td>8</td>
<td>Top of finished concrete level:</td>
</tr>
<tr>
<td>9</td>
<td>Date &amp; time of start and completion of boring:</td>
</tr>
<tr>
<td>10</td>
<td>Depth of Ground Water table in the vicinity:</td>
</tr>
<tr>
<td>11</td>
<td>Type of soil at pile tip:</td>
</tr>
<tr>
<td>12</td>
<td>Method of boring operation:</td>
</tr>
<tr>
<td>13</td>
<td>Detail of drilling mud as used:</td>
</tr>
<tr>
<td></td>
<td>a. Freshly supplied mud:</td>
</tr>
<tr>
<td></td>
<td>Liquid Limit:</td>
</tr>
<tr>
<td></td>
<td>sand content:</td>
</tr>
<tr>
<td></td>
<td>density:</td>
</tr>
<tr>
<td></td>
<td>Marsh viscosity:</td>
</tr>
<tr>
<td></td>
<td>Swelling Index:</td>
</tr>
</tbody>
</table>
pH value:
b. Contaminated Mud:
   Density:
   Sand content:

14. SPT (N) Values in soil (from the nearest bore hole)
    UDS value in rock (from the nearest bore hole)
15. Chiselling, if any From ..........M to ............M

16. Date and time of start and completion of concreting

17. Method of placing concrete

18. Concrete quality:
    Actual:
    Theoretical:

19. Ref. Number of test cubes

20. Grade and Slump of concrete

21. Results of Test Cubes

22. Reinforcement Details

   Main reinforcement        Stirrups: Type
   No. : ..................  No. : ............... 
   Dia....................  Dia. ............... 
   Depth ....................  Spacing ............. 

23. Any other information regarding obstructions, delay and other interruption to the sequence of work.
### TABLE - 1

**FREQUENCY OF SAMPLING AND TESTING**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type of Material/ work</th>
<th>Nature of test/ characteristics</th>
<th>Method of test</th>
<th>No. of samples &amp; frequency of test</th>
<th>Acceptance criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pile-bore size</td>
<td></td>
<td>Physical measurement</td>
<td>Each pile</td>
<td>Dia. As per drg. Length as established by initial test</td>
</tr>
<tr>
<td>a.</td>
<td>Diameter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>Length</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Bentonite (mud )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td>Basic properties of Bentonite before use</td>
<td>Liquid limit, Marsh viscosity, Specific gravity, Sand content, Swelling Index, pH value.</td>
<td>In laboratory</td>
<td>Minimum one sample consisting of 3 specimens once in a week.</td>
<td>As per clause No. 7.03.4</td>
</tr>
<tr>
<td>b.</td>
<td>Contaminated mud from pile- bore bottom before concreting</td>
<td>Density &amp; sand content</td>
<td>In laboratory</td>
<td>In each pile for first 10 piles before concreting in case of satisfactory results, the frequency may be reduced to one in 25 piles</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Position and alignment</td>
<td></td>
<td>Physical or any approved method.</td>
<td>Each pile</td>
<td>Density shall not be more than 1.25 Te/Cu.m Sand content shall not be more than 7% As per specification</td>
</tr>
<tr>
<td>4</td>
<td>Cleaning of pile – bore</td>
<td>As per clause No. 8.08.0</td>
<td>Each</td>
<td>Pile-bore should be free from bored materials/ cutting / debris</td>
<td>.Dispensary</td>
</tr>
</tbody>
</table>
## PROJECT __________________________

### PILE LOAD TEST: VERTICAL / HORIZONTAL / UPLIFT

<table>
<thead>
<tr>
<th>PILE No.</th>
<th>Date of cast</th>
<th>Type of equipment and method of boring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of pile</td>
<td>Commencement of test</td>
<td>Plan of test arrangement showing position and distance of kentledge, supports, tension or compression piles and reference frame to test pile etc.</td>
</tr>
<tr>
<td>Diameter</td>
<td>Completion of test</td>
<td>Type of test</td>
</tr>
<tr>
<td>Capacity</td>
<td>Capacity of jack</td>
<td>initial / routine</td>
</tr>
<tr>
<td>Type of test</td>
<td>Jack constant weight of kentledge</td>
<td>Loading Method</td>
</tr>
<tr>
<td>initial / routine</td>
<td>Reaction of pile details.</td>
<td>Direct / cyclic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Pressure Gauge</th>
<th>Load (M.Te)</th>
<th>Dial Gauge Reading</th>
<th>Average settlement</th>
<th>Net (mm)</th>
<th>Rebound</th>
</tr>
</thead>
</table>

Submission of Test Results
i) Time Vs. settlement
ii) Load Vs. Settlement including the Safe Load.
ANNEXURE VIII

QUALITY ASSURANCE PLAN
## QUALITY ASSURANCE PLAN

<table>
<thead>
<tr>
<th>SL No</th>
<th>MATERIAL/OPERATION</th>
<th>NAME OF TEST</th>
<th>FIELD/LAB.</th>
<th>TEST PROCEDURE</th>
<th>FREQUENCY OF CHECKING</th>
<th>EXTENT OF CHECKING</th>
<th>REFERENCE DOCUMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Earthwork in excavation</td>
<td>Lines, levels &amp; depth</td>
<td>Field</td>
<td>Measurement</td>
<td>As per decision of site engr.</td>
<td>100% Specn. &amp; approved drg.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Concrete work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Course aggregate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) % of soft or deleterious materials</td>
<td>Lab.</td>
<td>As per IS 2386 Part IX, 1963</td>
<td></td>
<td></td>
<td>-do-</td>
<td>Specn. &amp; IS 2386 (Pl.IX) &amp; IS-383</td>
<td></td>
</tr>
<tr>
<td>ii) Particle size distribution</td>
<td>Lab/Field</td>
<td>As per IS 2386 (Pl.I)</td>
<td></td>
<td></td>
<td>-do-</td>
<td>IS 383, Specn.</td>
<td></td>
</tr>
<tr>
<td>b) Fine aggregate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii) Particle size distribution</td>
<td>Lab/Field</td>
<td>IS 383</td>
<td>-do-</td>
<td>-do-</td>
<td>Specn. &amp; IS 383</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Cement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) Physical properties</td>
<td>Lab</td>
<td>As per IS 269 &amp; 4031</td>
<td>-do-</td>
<td>-do-</td>
<td>IS 269, 1489, 4031 &amp; test certificate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii) Chemical properties</td>
<td>-do-</td>
<td>As per IS 4032</td>
<td>-do-</td>
<td>-do-</td>
<td>IS 4032 &amp; test certificate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) Reinforcing bars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) Deformed bars</td>
<td>Physical properties &amp; dimensions</td>
<td>Field/Lab</td>
<td>As per IS 1139</td>
<td>-do-</td>
<td>-do-</td>
<td>IS 1139 &amp; test certificate</td>
<td></td>
</tr>
<tr>
<td>ii) Cold twisted bars</td>
<td>-do-</td>
<td>As per IS 1786</td>
<td>-do-</td>
<td>-do-</td>
<td>IS 1786 &amp; test certificate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii) Hard Drawn Steel Wire Fabric</td>
<td>-do-</td>
<td>As per IS 1566</td>
<td>-do-</td>
<td>-do-</td>
<td>IS 1566 &amp; test certificate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv) TMT bars</td>
<td>-do-</td>
<td>As per IS 1786</td>
<td>-do-</td>
<td>-do-</td>
<td>IS 1786 &amp; test certificate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>v)</td>
<td>Physical</td>
<td>Field</td>
<td>As per IS 456</td>
<td>ALL</td>
<td>-do-</td>
<td>IS 456 &amp;</td>
<td></td>
</tr>
</tbody>
</table>
### Placement, laps, hooks, spacers etc.

<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
<th>Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>e) Water</td>
<td>Chemical test -do-</td>
<td>As per IS 3025-64 Single Test -do-</td>
</tr>
<tr>
<td>f) Tests for concrete</td>
<td>Slump test Field</td>
<td>As per IS 1199</td>
</tr>
<tr>
<td></td>
<td>Cube test at 7/28 days Field/Lab.</td>
<td>As per IS 516 No. of cubes to be decided as per given in IS 456/Specn.</td>
</tr>
<tr>
<td>g) Shuttering/Formwork</td>
<td>Checking of levels, dimensions, unevenness, joints, cleanliness, oiling etc. Physical Field Measurement All</td>
<td>-do-</td>
</tr>
</tbody>
</table>

### 3. Brick Work/Hollow Concrete Block work

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Brick/ Hollow Concrete Block work</td>
<td>Physical properties &amp; crushing strength Field/Lab.</td>
<td>As specified in Specn &amp; IS 1077</td>
</tr>
<tr>
<td>b) Mortar</td>
<td>Uniformity in mix Field</td>
<td>As specified in IS 2250 As &amp; when required -do-</td>
</tr>
</tbody>
</table>

### 4. Steel works using tubular, angles, plates, channels etc.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Structural steel &amp; plates</td>
<td>Dimension, manufacturers, Specn. test certificates Lab.</td>
<td>IS:226 &amp; 2062</td>
</tr>
<tr>
<td>ii) Welding electrodes</td>
<td>-do-</td>
<td>-do-</td>
</tr>
<tr>
<td>iii) Welding</td>
<td>Quality of weld, weld reinforcement, contour etc. Field</td>
<td>Visual</td>
</tr>
</tbody>
</table>
5. Providing & laying water proofing on roof
   - Thickness, slope etc. -do- As per Specn. & IS 2115 -do- -do- -do-

6. Flooring
   i) Cement concrete floor
      - Physical, Field - As per IS 1443 -do- IS 1443
   ii) Glazed tiles
       - Physical, Field - As per IS 13630 -do- IS 13630 & Manufacturer's certificate

   - Physical -do- As per IS 277 & 513 Once for each source/supply -do- IS code, spec. & Manufacturer's certificate

8. Gypsum board false ceiling/ Prima board Armstrong false ceiling
   - Physical -do- IS 2095 & 2542 All -do- IS code, specn. & Manufacturer's certificate

9. Doors/windows/ventilators
   i) Glazing
      - Physical -do- IS 1081 & 2835 All -do- IS code, specn. & Manufacturer's certificate
   ii) Flush door shutters
       - Physical -do- IS 2095 & 2542 All -do- IS code, specn. & Manufacturer's certificate
   iii) Aluminium
        - Physical -do- IS 1948 & 1949 All -do- IS code, specn. & Manufacturer's certificate
   iv) Steel
       - Physical -do- IS 1038 All -do- IS code, specn. & Manufacturer's certificate

10. Plastering
    - Physical -do- As per specn. All -do- Specn.

11. White washing, snowmen, distemper
    - Physical -do- IS 712, 428 & 5410 All -do- IS code & specn.
| 12. | Toiletries & sanitary fixtures | Physical -do- | IS 771, 775, 774, 1239, 2065, 781, 1729, 1726, 651, 4127 etc. | All -do- | IS code, specn. & Manufacturer’s certificate |

Note: Parameters/guidelines fixed for the quality control in accordance with the contract document, IS Codes/Technical Specification etc. are just the synopsis of the whole constructional activities in a bid to visualise the total involvement at a glance. Mere compliance of the QAP does not relieve the contractor from overall responsibility to render best quality of work in conformity with all the relevant documents and the best engineering practices. In order to minimise the size of QAP, only salient/important features have been taken into account and other small/minor involvement will be dealt with individually as per the provision of contract.
SECTION : VI – 6.0

PROJECT EXECUTION PLAN,
PLANNING & SCHEDULE, INSPECTION

PLANT : STEAM GENERATION PLANT

PROJECT : INTEGRATED COAL BASED FERTILISER
COMPLEX, AT TALCHER, ANGUL DISTRICT,
ODISHA
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1.0. INTRODUCTION

The Joint Venture of four major Public Sector Units – M/s Rashtriya Chemicals & Fertilizers Ltd. (RCF), M/s GAIL (India) Ltd. (GAIL), M/s Coal India Ltd. (CIL) and M/s Fertilizers Corporation of India Ltd. (FCIL) has decided to build a world class Coal based fertilizer complex. The fertilizer complex will consist of Coal Gasification based Ammonia Synthesis Gas Plant and Urea Plant, and is to be built at Talcher, Angul District, Odisha (India).

To cater the requirement of steam for the above plants, Talcher Fertilizers Limited intends to set up “Steam Generation Plant based on coal feedstock” under one LSTK package.

Projects and Development India Limited (PDIL) has been retained as Consultant by TFL to provide services for the selection of LSTK CONTRACTOR.

LSTK CONTRACTOR is advised to visit and examine the site conditions and obtain for itself on its own responsibility all information that may be necessary for preparing the bid and entering into the Contract. Claims of any kind due to variation or ignorance of site conditions and environmental conditions will not be eligible in any circumstances.

1.1. General

This Lump-sum Turnkey package has been prepared as a Bidding Package to the extent enumerated in various sections and documents enclosed.

Detailed scopes of work and discipline-wise technical requirements are provided in respective sections of this Tender Document.

The Contractor will execute the project on Lump-sum Turnkey basis, in accordance with and supported by Process Engineering Procedures, Procurement Procedures, Construction Management Procedure, Project Controls and Computer System to be developed to affect the maximum efficiency of quality of the project. To achieve this goal and requirements of the Owner/PMC, Contractor will establish his project organization giving due consideration to the following aspects:

- Effective execution and timely completion of each phase of the project.
- Maintaining high quality in each phase of the project.
- Good relation and coordination between the Owner/PMC and the Contractor.
• Assignment of experienced resources and personnel for immediate and smooth launching of the project.

1.2. Engineering

Contractor’s scope of work includes detailed engineering, preparation of engineering drawings and datasheets, making use of standard specifications, standards, design guides and technical documents enclosed in this Tender Document. Technical requirements, technical documents, standard specifications, PMC standards and guides to be followed for different type of works shall be as provided in this Tender document.

Contractor to carry out the Detailed Engineering defined above. Commissioning of the project in totality is a part of Contractor’s scope. Engineering required to be done by the Contractor may arise singularly or in combination due to Manufacturing, Fabrication, purchased items, Construction, Commissioning, Statutory requirements, Government regulations, Safety requirements, site conditions, resultant total procurement and Construction, Installation and Testing, Insulation, Painting and Commissioning, etc.

1.3. Procurement

Contractor’s scope includes ordering, all import formalities, fabrication/purchase of equipment and materials, port clearance, packaging and transportation to site, stores management which includes preservation and storage of equipment and materials, uncovered storage. Items contemplated for fabrication at site to be submitted along with the bid although both these aspects would be covered under the Contractor’s responsibility.

Vendor manuals relating to installation, operation and maintenance and test certificates should be necessarily sent along with equipment. Please also refer Final Documentation Submission requirement spelt out in this Tender Document, in this regard.

Before ordering, clearances for technical portion would be taken from Owner / PMC in respect of the Critical Equipments (Special Equipments) comprising of Mechanical Static and Rotary Equipments, Electrical and Instrumentation items. Any ordered items which do not confirm to the contractual requirement identified at any stage of the project shall be rejected. Replacement / modification and project delay arising out of this shall be to the Contractors account.

Whenever clearances are to be taken, it would be necessary to submit details of technically acceptable offer.

Procurement of spares shall be as per spare part philosophy detailed in the scope of supply. Commissioning spares are also in the Contractor’s scope.
1.4. **Construction and Installation**

Contractor's scope covers detail engineering including barricading of the allocated area complying with statutory norms, construction, installation and commissioning of the unit as per P&IDs, datasheets, drawings, standards, specifications, codes, statutory and state regulation. Supply of construction materials, labour, labour supervision, tools, tackles, consumable materials and accessories not specifically mentioned herein but nevertheless necessary, as per the PMC for the construction, installation, testing and commissioning of the complete system including cranes or any other material handling equipment is also part of Contractor's scope.

1.5. **Commissioning**

Contractor's scope covers supply of all initial fill such as lubricants, seal oils, chemicals, consumables, spares required for start-up, pre-commissioning and commissioning of the project. Contractor shall arrange necessary loading / unloading equipments for undertaking this activity. The scope also includes providing manpower (skilled as well as unskilled) and organisation for commissioning and is to be indicated along with the bid.

1.6. **Quality Assurance**

The desired quality is to be met for different activities at various stages of the project. The quality checks by Owner and PMC could be of audit type / involvement at all stages of project execution by the Contractor and details of the quality plans will be furnished along with the bid. Contractor is required to submit detailed Quality Control (QC) measures to be adopted by him for all stages/types of activities. A notice period of six weeks is to be given for imported items and one week for indigenous items for association with respect to witness QC steps by Owner / PMC. Detailed methodology is enclosed in Tender Document for compliance. Facilities at shops / site / Engineering office for carrying out quality checks by Owner/PMC shall be provided /organised by Contractor.

1.7. **Statutory Approvals/State Regulations**

Statutory regulations as required during pendency of the contract will be adhered to for engineering, preparation of drawings/documents, fabrication, manufacturing, purchased items, construction and commissioning. Documents as required will be generated and submitted for the approval of statutory authorities. Follow up and obtaining clearances shall be responsibility of the Contractor.

State regulations as and when applicable for different phases of the project shall be adhered to by the Contractor. Statutory approval from any authority as per statutory rules and regulations of Central/State Government shall be the Contractor's responsibility unless otherwise specified in bid documents. The application on behalf of Owner/PMC for submission to relevant authorities along with copies of required certificates complete in all respects shall be prepared and submitted by the Contractor well ahead of time so that the
actual construction / commissioning of the work is not delayed for want of approval or inspection by concerned authorities. The inspection of the works by the authorities shall be arranged by the Contractor and necessary coordination and liaison work in this respect shall be the responsibility of the Contractor. Statutory fees paid, if any, for all inspections and approvals by such authorities shall be borne by Contractor.

Any changes/additions required to be made to meet the requirements of statutory authorities shall be carried out by the Contractor free of charge. The inspection and acceptance of the work by statutory authorities shall however, not absolve the Contractor from his responsibilities under this contract.

1.8. Project Management

The project management services will include Planning, Scheduling, Monitoring, Progress Reporting, Quality Assurance and Quality Control and Overall Project Management functions. Contractor shall nominate a Project Manager who will be responsible for the total scope of work under this contract and shall respond to Owner and PMC’s Project Managers on all matters relating to this contract.

The Contractor is expected to execute the Work/Services under this contract on Task Force concept with a dedicated team of specialists who will be responsible and respond to the Project Manager.

The Task Force shall be so organized as to give effective management and control of various services to the Project Manager.

1.9. Organization

The organisation up to working level including period envisaged for different phases of the project engineering, ordering, follow up for manufacture of equipment, clearances, transportation, inspection of equipment and materials, warehousing, safety, construction, commissioning coordination with statutory authorities and government authorities and project management will be submitted along with the bid. Bio-data of key personnel will also be submitted with the offer.

1.10. Safety

All measures required for safe constructions are to be taken and the schemes are to be approved by Owner/PMC before commencement of works. Besides, all personnel employed on the job are to follow safety requirement of Owner/PMC and state regulations as applicable from time to time. A list of safety implements/equipment proposed to be used by the Contractor, are to be indicated along with the bid. At least one safety engineer in each shift, for the project, shall be provided by the Contractor.
Safety report generation for different situations as per rules and required by Owner/PMC are to be adhered to. Copy of safety practices to be followed during construction is enclosed in this Tender Document. Contractor shall comply with the provisions of this document. This document specifies broad guidelines on safe practices to be adhered to during construction activities. However, before commencing any job, specific hazards and its effects should be assessed and necessary corrective/preventive action should be taken by the Contractor. This document shall supplement the prevailing statutory requirements, which shall also be followed as applicable.

1.11. Sequence for Decisions

Along with bid submission, it is necessary for the Contractor to bring out variation, if any, in related data sheets, drawings, specifications, standards, codes, scope, any other contractual clauses and seek clarifications from PMC/Engineer-In-Charge. The decision of the PMC shall be final and binding on the bidder in such cases. For those such items, which arise during execution of the project, the stringent specification/standards will be applicable, and shall be binding on the Contractor. However, the decision of the PMC/Engineer-in-Charge shall be final and binding on the Contractor.

1.12. Vendor List

All items required for project are to be purchased through approved vendors of Owner/PMC, wherever such details are not available, vendor list to be proposed by Contractor and clearance to be obtained from Owner/PMC before initiating the ordering process.

1.13. Waste Disposal / Scrap etc.

All waste generated which could be surplus earth after use and or surplus construction materials will be disposed off from time to time as directed by Owner/PMC.

1.14. Environmental Management System

Bidders should comply with the latest relevant elements of the International Standard for environmental protection, as applicable to their scope of work.

2.0. PROJECT MANAGEMENT AND EXECUTION

2.1. Project Management

Plot plan, detailed technical requirements along with the detailed scope of work and overall proposed implementation schedule is issued by Owner / PMC. These will form the basis for formulation of the Overall Project Master Schedule of the plant by Contractor. The Contractor is required to organise his services in a systematic manner to ensure execution and completion of the unit as per the schedule. The bidder is required to submit along with
his bid the methodology/procedure proposed by him for this unit together with the organisational set up proposed and bio-data of key personnel.

In order to achieve uniformity in execution of various activities of the project, PMC has developed engineering design basis and project procedures/methodologies to be adopted by the executing agency. The Contractor is required to carry out detailed engineering, procurement, tendering, construction supervision and management, planning scheduling, monitoring, reviewing, reporting, and overall project management activities. All activities to be performed and services to be rendered by the Contractor under this contract shall be monitored by Owner / PMC and will be subject to periodic reviews by PMC. The Contractor shall facilitate such reviews/monitoring by Owner / PMC.

Immediately after the award of job, a Kick-Off Meeting will be held to finalise and establish the modalities and procedures to be adopted for execution of the contract based on the enquiry document, commitments made by Contractor and subsequent agreements reached between Owner/PMC and Contractor during negotiations. The Kick-Off Meeting will be attended by key members of Owner/PMC and Contractor. This will address all necessary details and arrangement between Owner/PMC and the Contractor.

The Contractor’s service for Engineering, Procurement, Tendering, Construction, Supervision and Management, Planning, Scheduling, Monitoring, Reporting, and Overall Project Management shall meet the requirements given in this section.

English language and Metric Units shall be used in all documents, drawings, reports, correspondences etc. under this contract.

### 2.2. Detailed Engineering Services:

The Contractor shall provide the detailed engineering services for the project as mentioned in this bid document furnished by the Owner/PMC. The services shall cover the detailed engineering required for execution and completion of the project along with the utilities to be provided inside the battery limit of the Plant.

All critical drawings / documents to be prepared by Contractor/sub-contractors/vendors as per given in the bid document for review and approval by Owner / PMC. Obtaining all such approvals shall be the responsibility of the Contractor and the same is included in his scope of work. Such review and approval by Owner/PMC shall, however, not relieve the Contractor of his responsibilities.

For achieving the project schedule, it may be necessary in some cases to prepare the drawings in stages and release it for construction so as to take up simultaneous execution of detail engineering and construction. Any revision involved for the above is included in the scope of work of the Contractor. Also any change required to meet site conditions/statutory requirements shall have to be carried by Contractor at no extra cost.
The Contractor is required to organise a Task Force of dedicated specialists from each discipline under a Project Engineering Manager who will be assisted by engineering Coordinator. An engineering schedule will be prepared and submitted to Owner/PMC for approval. This approved schedule shall be used for all engineering activities. The engineering coordinator shall coordinate all design and engineering activities and interact with purchase, inspection, expediting, C&T, tendering, planning, construction and project groups. His responsibilities shall include.

(a) Engineering coordination for procurement involving:

- Preparation of Material Requisitions (MRs).
- Technical evaluation of offers received (which may involve technical discussions with vendors and concerned specialists may have to be deputed to vendors works or to Owner/PMC’s offices as per requirements) and preparation of recommendations.
- Preparation of Technical Purchase Requisition (PRs) on selection of vendor.
- Review/approval of vendor drawings/documents. (This may call for arranging specialist visits to vendor’s works for timely approvals of critical items.)

(b) Engineering coordination for sub-contractors involving:

- Preparation of schedule of quantities and specifications for various contracts.
- Technical evaluation and recommendation of offers received. This may involve arranging technical discussions with Tenderers at Owner/PMC’s office if called for due to job requirements.
- Preparation of technical-agreed variations for incorporation in contracts for the selected Contractor.

In any case, Contractor has to take owner approval for sub-contractors list prior to scrutiny and award.

(c) Engineering coordination for construction involving:

- Timely issue of approved construction drawings including drawings duly approved by Owner/PMC as per requirements.
- Providing/arranging clarification on drawings and specifications wherever called for including specialists visits to site.
- Making regular periodic visits to project site for review of site requirements in respect of engineering activities.
• Attending/arranging for discussions with statutory authorities such as Chief Electrical Inspector, Chief Inspector of Boiler, Tariff Advisory Committee, etc. to arrive at design basis/documents acceptable to them wherever required for obtaining statutory approvals and any other local approvals.

(d) Monitoring progress of engineering activities and advising Project Manager on shortfalls and corrective actions needed. He will also attend the review meetings.

Detailed engineering and construction shall be based on sound engineering practices. List of applicable codes, standards and mandatory rules to be used in design is also mentioned in bid document.

Drawings/Documents/MRs etc., which are to be generated by Contractor shall be numbered as per the Documents Numbering Procedure of Owner/PMC.

Head Office engineering support of Contractor shall be provided to site during construction including deployment of engineering specialists for field engineering as and when required by Contractor.

2.3. Procurement

The procurement services to be provided by the Contractor shall cover the purchasing, inspection, expediting, custom clearance and transportation activities

(a) Purchase

The purchase activities will cover all equipments and materials required for completion of the project. The purchase group shall consist of adequate number of experienced and qualified Purchase Officers commensurate with the number of material requisitions to be handled and the time schedule for ordering. A procurement schedule will be prepared and submitted to Owner/PMC for approval. This approved schedule will be followed for all procurement activities.

Purchasing activities shall be coordinated by an experienced purchase coordinator who shall be responsible for:

• Coordinating with engineering group regarding preparation of material requisitions (MRs), evaluation and clarifications on offers of vendors, technical discussions, negotiations with vendors, technical recommendations preparation of purchase requisitions to form part of purchase requisitions selected vendors purchase order.

• Coordination for processing of change orders as required during execution of the project on account of additions/modifications as well as transit losses/damages.
• Before ordering, clearance for technical portion for rotating, instrumentation and electrical items as indicated in technical details would be taken from PMC.

• Preparation and issue of status reports on purchasing activities.

• Attending review meetings with Owner/PMC on all purchase activities.

(b) Inspection and Expediting

The Contractor is required to organise a proper inspection and expediting system so as to ensure timely delivery of all the items/equipment meeting the specified quality criteria. This function has to be carried out by appropriate deployment of qualified personnel who have wide experience in their respective fields. Owner/PMC will reserve the right to inspect items deemed necessary by them without any additional cost to Contractor/sub-contractor/vendor/third party.

Expediting is one of the vital activity of successful and efficient procurement system which enables timely execution on the project. Such expediting has to be carried out by deployment of expediting coordinator located at Contractor's Head Office who would be assisted by expediters located in various regional offices. To enable this function to be very effective and fruitful, following functions are to be carried out as a minimum.

Expediting Coordinator

Expediting Coordinator located at the Contractor’s HO will liaison with various departments such as purchase, projects, engineering, transportation etc. on one hand and regional inspection/expediting offices and vendors on the other. The basic functions of such expediting coordinator would be:

• Maintain effective communication link between various departments of the Contractor including his regional offices and vendors on whom the orders are placed.

• Status maintenance of all the orders.

• Analyzing the order status in detail after identifying the critical order and initiation of suitable remedial measures.

• Acting as an effective instrument in final delivery of the item within CDD.

• Preparation of order close out reports of each order.

• Expediting coordinator shall be a person who is highly communicative and has sound technical knowledge; he must be highly analytical, alert, quick in gathering up-to-date information of the various orders.
Responsibility of Expediting Coordinator

- Attending periodical review meetings with Contractor’s project department and Owner/PMC.

- Distribution of Fax of Intent/Letter of Intent and status maintenance.

- Liaison with regional offices to obtain order to generate acknowledgement of Fax of Intent/Letter of Intent.

- Intimate Owner/PMC of reservations (if any) from the vendor in purchase order acceptance.

- Distribution of POs / PRs to vendors and regions.

- Expediting of vendor’s drawings and other related documents.

- Expediting of approval of drawing by respective engineering department and timely return of the same to the vendor.

- Ensure receipt of periodical expediting reports and preparation of monthly status report against each order as per the requirement of Owner/PMC.

- Identification of critical orders/issues and initiate of remedial action.

- Expediting of decision on deviation sought by the vendor.

- Follow up actions with various concerned departments regarding all the issues discussed in the review meetings.

- Prompt despatch of material after inspection with the assistance of transportation department.

- Follow up of despatch particulars after despatch.

- Ensure preparation of order close out report for each order giving complete details of the order including ordered quality, contractual delivery date (CDD).

- Date of completion, delay, if any and reasons for delay, status of final documents etc.

- Ensure receipt/distribution of vendor documents including final documents as per PR.

- Preparation of final procurement closing report. The order close out reports shall be accompanied with two sets of complete documents in respect of each order bound/put together in a folder comprising of: purchase order, purchase requisition, change orders (if any), inspection certificates, material test certificates, final vendor drawings (if applicable), operation/maintenance manuals, any other document as specified in PR.
Expeditor

Expeditor’s responsibility commences from the time he receives the intimation of placement of TOI/LOI/order on vendor located in his region till the time he furnishes the despatch particulars of the item under a particular PO. During this process expeditor shall monitor and maintain all activities of the vendors such as:

- Vendor’s understanding of the order.
- Submission of design drawing documents for approval.
- Sub-ordering, planning and scheduling.
- Manufacturing testing and despatch.
- Delays, power cuts, strike lock out etc.
- Submission of final documents as per PR.

Above functions may be possible only by frequent visits to vendor’s office and shops including their sub-vendor’s establishments as the case may be. Expeditor shall be able to visualise the problems in advance and suggest timely corrective measure. In nutshell, expeditor is not a mere progress reporter but a vital catalyst for successful completion of the job. Expeditor’s responsibilities are as below:

- Ensure order acknowledgement from the vendor.
- Communicate the person concerned the reason for vendor’s inability to accept the order (if so).
- Progress reporting of various orders located in the region.
- Communication with the vendors whenever he finds lack of efforts on their part.
- Raise alarm report at an appropriate time on possible serious delay or vendor’s inability in meeting with scheduled date of delivery and also to suggest action plan.
- Liaise with inspection department for timely inspection, including third party inspection/statutory inspection as specified/required.
- Liaise with engineering department for approval of drawing, acceptance of deviation etc. through the expediting coordinator.
- Liaise with transportation department for sound and quick despatch of material.
(c) Inspection Quality Assurance System

The objective of the quality assurance scheme of the Contractor shall be to ensure the conformity of equipment, material, site construction (if any) to various standards, specifications, drawings and technical requirements that are being mutually agreed between the Contractor and Owner/PMC. Quality Assurance System should clearly indicate the organisational approach for quality control and quality assurance of the various equipment/construction activities (if any) and also provide a verifiable evidence of the Contractor having carried out all the activities laid down in the bid document and the procedure. Such conformity to quality level shall be ensured by controlling the quality level of purchased items at vendor's/sub-vendor's shop/site and shall cover from source surveillance to final inspection. The Contractor to submit a detailed inspection and testing plan for various shop/site activities as a part of his Procurement Manual which shall be duly approved by Owner/PMC. The Procurement Manual shall as a minimum include:

In house Inspection Programs

- Inspection procedures consistent with mandatory codes.
- Procedures for material identification and transportation.
- Certification of non-destructive testing.

Inspection responsibility shall include but not be limited to the following:

- Single or multiple visits to the vendor's shop/site as per the requirement.
- Pre-inspection liaison meeting with the vendor for vendors correct understanding of the inspection requirements.
- Approval of quality assurance/quality control plan procedure clearly indicating stages of inspection with specific reference to witness and review.
- Ensure submission of quality control procedure and approval of the same for critical sub-orders.
- Inspection of various equipment/items as per relevant codes, specifications/drawings including witnessing of final acceptance test at vendors works/site.
- Maintenance of inspection reports periodically highlighting hold, deviation etc.

As indicated for expediting coordinator, Contractor should nominate an inspection coordinator with similar responsibility who will liaise various inspection offices/vendors for proper coordination.

Inspection through an Approved Third Party Inspection Agency
Inspection requirements shall be fulfilled through Owner/PMC approved Third Party Inspection Agency. The payments to be made to the Third Party Inspection Agency shall be the responsibility of the Contractor. Further, the responsibility for inspection/testing as per specification approved documents and agreed Quality Assurance procedure and plans shall be that of the Contractor. Inspection activities of the Third Party Inspection Agency shall be coordinated by the Inspection Coordinator of Contractor.

(d) Customs Clearance and Transportation

The Contractor is required to organise a custom clearance and transportation (C&T) system to ensure prompt clearance of imported equipments from customs and transportation of equipments/materials to project site from ports/vendors works. This function shall be carried out by deployment of qualified and experienced personnel. C&T functions shall include, but not be limited to the following:

Appointment of Contractors

- Clearing forwarding of imported equipments/materials.
- Collection and transportation of bulk materials by road from vendor’s works.
- Transportation of consignments from port to site by road.
- Handling of consignments at project site.
- Transportation of general cargo and over dimensioned consignments by road/rail wherever applicable.
- Clearing and handling of air consignments, if applicable.
- Any other contracts relating to C&T services.

Supervision of Contractors

Supervision, monitoring and coordination of above contracts for import clearance and transportation as detailed below by Contractor. EC (Essentiality certificate) shall be provided by Owner to main Contractor of Indian origin. Essentiality certificate is not applicable to foreign Contractor.

Import Clearances

- Monitoring and coordination with clearing agents, customs, ports, steamer agents, airlines, railways and transport agencies for clearance of imported consignments.
• Registration of contracts with customs under project imports.

• Control of payment of import duty to customs, payment of port dues, etc.

• Conducting surveys with various agencies for imported consignments landed in damaged condition and corrective action for timely replacement of items.

Despatch of Indigenous Project Goods

• Coordination with inspection/expediting group and all indigenous suppliers for expeditious despatch of consignments.

• Monitoring movement of consignments from vendors works to project sites.

• Collection, transportation and delivery of bulk-material to project site.

(e) Monitoring Movement of Consignments

Total monitoring of movement of all consignments dispatched to project site from various points of despatch. A chaser has to be deployed from Contractor, for transportation of all ODC Consignments as well as important consignments (imported and indigenous) as and when advised by Owner/PMC.

(f) Reporting

Preparing and issuing Weekly, Fortnightly and Monthly Status Reports on clearance of imported equipments/materials and movement of equipments/materials from various despatch points to project site.

Monthly Reports on Over/Short Rejected/Damaged (OSRD) items. It shall be Contractor’s responsibility to arrange for timely replacement of OSRD items.

(g) Tendering

Tendering activities of the Contractor shall be properly organised to ensure award of various contracts in line with the project schedule. The tendering group shall consist of sufficient number of contract engineers/officers who are having adequate professional experience and qualifications.

Contractor shall prepare a Tender schedule for carrying out different works such as civil and structural equipment erection, piping, electrical, instrumentation, painting etc. All tendering activities shall be carried out in accordance with this approved tender schedule. The Contractor shall deploy a contract coordinator for coordination of tendering activities. The contract coordinator shall be responsible for:
• Coordinating with the Resident Construction Manager during execution of the contracts regarding clarifications on contract terms and conditions as required.

• Preparation and issue of status reports on contracting activities.

• Attending review meeting with Owner/PMC on all contracting activities.

• Preparation of tender documents, issue of enquiry to approved Contractors through receipt of bids, techno-commercial evaluation of offers for award of contract will be carried out by Contractor.

All major tenders will be handled by the Contractor from his Head Office. However, tenders for certain minor construction will be handled by Contractor’s site office.

The Contractor is required to institute and maintain a proper planning, scheduling and monitoring system and employ professionally qualified and experienced planning engineers for the project. The system shall have latest state of the art technique. To this effect, Contractor shall implement this system through the Prima Vera Project Planner. The system developed should be capable to support and enforce proper control mechanism in the project. It should be based on hierarchical breakdown of works with elaborate level of detailing and control. The levels of controls should be such that it supports and fosters controls at activity level, function level and management level with greater emphasis on target, scope and commitment at various stages of contract for accountability and action planning, such multi-level/multi-tier system of planning, scheduling and monitoring, supports, effective information generation, assimilation, summarisation and reporting in proper and adequate manner.

The system shall be predictive type and should constitute pre-warning mechanism to diagnose and anticipate the problem well in advance and provide preventive features/measures. It is required that work breakdown structure should consist of details of systems, work packages, functions, work items and activities from monitoring point of view at micro level and summarisation at higher levels. It is expected that the work breakdown structure coding system or methodology to be followed shall be informed/discussed with the successful bidder during the kick-off meeting.

2.4. Kick-Off Meeting

On award of job, the Contractor is required to submit the following documents which will be discussed during the kick-off meeting to establish planning requirements, inputs and outputs for overall schedule, monitoring and progress reporting.

• List of work package/areas.

• List of critical drawings.

• Breakdown of work packages to work items level.
• Input requirements of each work item/activity.

• Schedule start and finish dates of all milestone/activities in line with overall schedule of the project.

• Procedure for Project Planning, Scheduling, Monitoring & Control System including all reporting formats.

• Progress Measurement Methodology and Unit, Function, Discipline and Deliverable wise weightages breakdown. Overall system-wise, discipline-wise weightages for each item/activity.

• Procedure/presentation on proposed Bulk material control system

• Three month Front-End Schedule within a week of award.

In this kick-off meeting, it will be endeavoured to reach complete understanding with Contractor on activities, inputs and logic to establish planning documents for monitoring. Venue of the kick-off meeting to be held between the successful Bidder, PMC and the Owner, shall be either at PMC Office or Owner Office.

2.5. Early Planning Document / Look Ahead Schedule

Immediately after the award of contract and pending finalisation of overall project schedule, detailed activity chart/network, functional schedules etc., the Contractor in consultation with PMC shall prepare a look ahead schedule as a guideline for the activities to be performed during the relevant periods.

2.6. Overall Project Schedule

The Contractor shall submit within 30 days of Fax of Intent / Award of Work, the Work Breakdown Structure (Plant wise / Facility wise) showing project work load, that is, preparation of tenders, material requisitions, construction drawings equipments etc. alongwith a sufficiently detailed overall project schedule in the activity network form, clearly indicating the major milestones, inter relationship/interdependencies between various activities such as process, engineering, procurement tendering, manufacture, delivery, construction etc. together with computer analysis of critical path and floats as well as quantum of work for major activities.

The time and the date of completion of the works as stipulated in the CONTRACTOR's proposal and accepted by the OWNER shall be deemed to be of utmost importance. The CONTRACTOR shall so organise his resources and perform his work as to complete it not later than the date agreed to.
The CONTRACTOR shall submit The detailed Primavera Level 4 Project Master Schedule within thirty (30) days or as specified elsewhere after effective date of the CONTRACT.

The Primavera Level 4 Project Master Schedule shall be for OWNER / PMC review and be based on a Proposal Schedule as attachment to the CONTRACT. Such Proposal schedule shall show the execution periods for (i) Engineering, (ii) Procurement & Delivery of Equipment and Materials, (iii) Construction & Erection and (iv) Commissioning, Testing.

Bidding consortium shall be contractually obliged to issue a Primavera Level 4 Project Master Schedule, provided that such schedule shall not (i) accelerate the OWNER obligations (to be agreed upon prior to Contract award) (ii) change the agreed GUARANTEED COMPLETION DATE (date to be agreed upon prior to Contract award).

The above Primavera Level 4 Project Master Schedule shall be periodically updated,& reviewed and reports shall be submitted by the CONTRACTOR as directed by the OWNER / PMC.

The schedule will be reviewed and approved by Owner/PMC and the comments if any shall be incorporated in the network issued for implementation within two weeks from receipt of comments. The network thus finalised shall form part of the Contract and will become the basis for developing further detailed activity network. This schedule shall not be revised without the prior permission from the Owner/PMC during the entire period of contract. The changes made during revision of the contract shall be approved by Owner/PMC.

2.7. Detailed Activity Network

The Contractor should develop Detailed Activity Networks for various systems of the project, based on approved Overall Master Project Schedule. Such networks would be computerised for further monitoring and reporting.

2.8. Functional Schedules

The Contractor should prepare resource-based detailed functional schedules in line with detailed activity networks for functional monitoring, scheduling and control. This should clearly reflect strategies and philosophy of execution. Owner/PMC reserves the right to check the functional schedule and status of activities at anytime and at any location of performance/execution. Further, the functional schedules shall be submitted by the Contractor on demand by the Owner/PMC.

2.9. Progress Measurement Methodology

The Contractor is required to submit during the Kick-Off Meeting, the detail Methodology of Progress Measurement of Engineering, Procurement, Manufacturing, Delivery,
Computation of total Service/Physical Progress at the unit-wise level and on the overall basis. The progress basis shall be physical realisation of work such as in terms of deliverables and construction quantity/volume accomplished. The amalgamation of such output across the project to compute overall progress shall be suitably established with proper rational and norms and maintained throughout the project. Owner/PMC reserves the right to modify the methodology in part or in full.

2.10. Vendor Scheduling and Monitoring

The Contractor shall establish schedules for Pre-Ordering and Post Ordering for follow up. The vendor monitoring preferably should be on logical networks and commitments at least on critical items in order to monitor them on regular basis for effective control. Owner/PMC may demand such follow up procedure and logical networks for various Critical Equipment at any time during the course of order execution. The manufacturing schedule shall be established and agreed with the vendors and acceptance shall be brought to the notice of Owner/PMC in time.

2.11. Construction Network

The Contractor shall prepare and submit a Detailed Construction Network with full consideration of logistics, construction studies and method for Owner/PMC approval. The Contractor shall describe the resources required and special construction equipments, Tools and tackles to be mobilized. The network shall be developed subsequent of substantial progress of engineering and ordering with fairly known construction workload and quantities.

2.12. Construction Worksheets

The Contractor shall further detail out the construction network into area-wise details in terms of work, quantity and schedule, to firm up basis for area control. The construction schedule should be worked out based on work front generation criteria which will call for availability of input like drawings, materials and access for each/group of activity to be performed. It may be in the form of resource loaded bar chart with ‘S’ curve. Owner/PMC reserves the right to access the same.

2.13. Construction Contractor Schedule

The Contractor shall agree upon the construction schedules with sub-contractors for proper mobilisation, monitoring and control. Owner/PMC reserves the right to ask for such programme and status of any time as may be required.

2.14. Computerisation

Contractor should follow proper computerised control for the following project modules:
- Activity network
- Engineering (Residual)
- Purchasing, delivery and expediting
- Tendering
- Construction planning and control
- Materials control at head office.
- Material allocation and control at field office
- Proper warehousing control
- Project documents and construction drawings

The above distinct but integrated components of project should be monitored as deliverable and quantum level. To perform such elaborate level of input-output control at each deliverable, the packages used should forecast resources based on recovery plan in dynamic manner for adequate control.

As indicated earlier, Project Schedules as above shall be developed/evolved using the Latest Version of the Primavera (P6) Project Planner Software Package.

2.15. Project Review Meetings

Contractor shall present programme and status at various review meetings as required.

**Monthly Review Meeting**

<table>
<thead>
<tr>
<th>Level of participation</th>
<th>Project and planning of PMC, OWNER and Contractor</th>
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<tbody>
<tr>
<td>Agenda</td>
<td>Monthly Programme v/s Progress Status/Statistics</td>
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<td>Areas of concern and critical issue</td>
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<td>Recovery Action Plan</td>
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<tr>
<td>Venue</td>
<td>Owner / PMC Office or As Mutually Agreed Venue</td>
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</tbody>
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**Weekly Review Meeting**

| Level of participation | Contractor / PMC’s site in-charge / Project Manager and Job Engineers |
2.16. Progress Reporting

The Contractor shall submit the following Progress Reports on a regular basis for Owner / PMC review.

**Monthly Progress Report**

This report shall be submitted on a monthly basis within seven calendar days from cut-off date, or as agreed upon, covering overall scenario of the project. The report shall include, but not limited, to the following:

- Executive summary or summary of major events/activities.
- Schedule v/s actual percentage progress and progress curves for engineering, ordering, manufacturing, delivery, contracting, construction, commissioning, overall.
- Areas of concern/problem/hold-ups, impact; recovery action plans/catch-up plans.
- Activities executed achievements during months and targets for the following month.
- Analysis of critical activities and impact on overall completion.
- Chronological achievements of key events indicating schedules and actual date.
- Annexure giving status summary for drawings material requisitions, equipment and materials delivery, contracting and construction.
- Resource requirement deployment status.
- Statutory requirements / compliance status
- Change order status.
- Invoice status.
- Construction photographs.
- Updated Project Schedule
Weekly Reports

This report will be prepared for Head Office and construction site in summarized fashion and submitted on every Tuesday taking status as of Sunday by the Contractor on weekly basis and will cover following items:

- Activities completed (engineering, procurement, contracting, construction, etc.)
- Programme for subsequent week.
- Resource deployed – man and machine.
- Quantities and productivity achieved in key areas of work.
- Progress on procurement activities including material requisition status reports.
- Constraints, if any.

The report/information may be transmitted preferably through fax to Owner / PMC HO.

Daily Reports

- Important activities for the day at site.
- Engineering Deliverables Status
- Material/equipments receipts for the day.
- Labour deployment report.

2.17. Material Control

It is essential that the Contractor follow an integrated material control system for the project. In the system, material identification in the drawing office, procurement and allocation, are all channelized and controlled in an orderly manner. The Contractor should follow a system for material identification like system-wise or area-wise/zone-wise, and should give construction orientation to material control. The Contractor, right from the beginning, at the drawing office stage will start identifying materials system-wise or area-wise. The system will be based upon backing of material from the material take off stage through material requisitioning, placement of purchase order, manufacturing at vendor’s shop up to receipt at site for making the material available for performing planned and sequential construction work.
At the construction site, the Contractor will develop and implement a system of inspection, receipt and effective utilisation of materials received by re-examining the work front availability and priority between and amongst various systems and areas.

In the case of multiple agencies carrying out construction at site, the Contractor must adopt methodology of allocation and de-allocation and timely issue of the materials thereby preventing possible idle storage of items at the Contractor’s level. Contractor must follow proper warehousing procedure at project store to maintain various planned and unplanned issues and dynamic stock status records. Through periodic reviews, the Contractor will have a system of generating hold up reports well in advance to identify exception on material availability and to track such material by the expeditery through a systematic follow up procedure from the vendors.

Owner/PMC may introduce checkpoints at procurement, allocation and construction stages to know the development, status and behaviour of the system and the Contractor shall submit the following reports on monthly basis: bulk material status report, and material hold up/shortage report.

2.18. Project Time Control Methodology

2.18.1. The time for completion of the complete scope of work shall be strictly as per the time schedule given in the tender document.

2.18.2. The CONTRACTOR shall furnish the following documents along with the bid:

(a) An overall schedule in the form of network, clearly indicating all important milestones in design, engineering, fabrication, procurement construction, testing, commissioning, etc. for the plant commensurate with the overall time schedule.

(b) Resource deployment schedule indicating mobilisation of all critical resources including manpower and machinery for the smooth execution of the job at engineering offices, fabrication shops and construction site. The resource schedule shall also contain various construction aids envisaged to be deployed for execution.

(c) Organisation structure for effective project management and control, clearly indicating the responsibility centre as well as bio-data of the key personnel, who are permanent employees of the Contractor.

2.18.3. Within 30 days of issue of fax/letter of intent, the Contractor shall finalise the following as detailed earlier:
(a) Overall Project Schedule

Overall project schedule in line with the agreed milestone and detailed to adequate work breakdown structure level covering all phases of the work such as detailed engineering, procurement, manufacturing, shipment, tendering and field erection. This schedule shall also include the interface activities to be provided by the Owner/Engineer-in-Charge and the dates by which such facilities are needed. Contractor shall get the schedule reviewed by Owner/Engineer-in-Charge and the agreed schedule shall form part of the Contract monitoring document based on which performance would be reported and evaluated. This document shall be signed by both the parties. The Owner/Engineer-in-Charge shall also review the weightage allotted to various activities and method of reporting to be adopted by the Contractor. During the progress of the contract if in the opinion of Owner/Engineer-in-Charge, desired progress as physically/sequentially is not maintained, it would be obligatory on the Contractor to re-programme the work schedule in order to accommodate the backlog and/or provide work front to other agency, without any obligation to the Owner/PMC.

(b) Functional Schedules

- **Engineering Schedule**

  This shall indicate list of drawings, specification and sketches to be prepared discipline wise for each plant and scheduled date of issue of each document.

- **Ordering, Manufacturing & Delivery Schedule**

  This will be in the form of bar chart and shall indicate item-wise all the major activities regarding ordering, shop fabrication/manufacturing and delivery of materials.

- **Construction Schedule**

  This will be in the form of a detailed bar chart showing all the construction activities (civil structural, piping, equipment erection, electrical, instrumentation, insulation, painting, etc.) at site with their durations and workload and highlighting the inputs namely drawings, materials availability, etc., compatible with the related functional schedule. The Contractor shall provide on request key construction net work of any work module for critical review and control.

- **Resource Deployment Schedule**

  A detailed deployment schedule indicating manpower, machinery, construction, equipment in line with the overall project schedule.
• Pre-commissioning and Commissioning Schedule

Contractor shall develop this schedule in the form of a bar chart and submit the same to OWNER / PMC for review.

• Any other document required for monitoring.

2.18.4. In line with the construction schedule, the Contractor shall submit a monthly programme for site activities and the target set in shall be strictly adhered to. In all matters concerning the extent of targets set out in the monthly programme and the degree of achievement, the decision of PMC shall be final and binding. The monthly programme shall be further broken into weekly programmes. At the end of each week, a report shall be submitted by the Contractor indicating the achievement during the week against the targets, reason for shortfall if any and the construction programme for the following week. Contractor shall also attend weekly/monthly review meeting conducted by PMC or by his representative to review project status.

2.18.5. The Contractor shall regularly submit a detailed progress report in respect of:

- Release of drawings
- Sub-ordering of materials
- Manufacturing
- Delivery of equipment/material status report
- Construction
- Other features like mobilisation, safety etc.
- Report indicating the critical activities governing the timely completion of the project and actions to overcome the same to be submitted every month.

This report will be issued every month on an agreed cut off date and shall include the following brief description of the progress achieved during the month. Reason for short fall if any and action plan to make up short-fall.

- Scheduled and actual percentage progress discipline-wise/system-wise as well as overall physical progress.
- Job completion trend in the form of updated overall schedule.
- Progress photograph highlighting major achievement.
2.18.6. The Contractor at any point of time of operating would be permitted to revise the accepted schedule/control documents with the Owner/Engineer-in-Charge without changing the contractual completion date.

2.18.7. The review of the performance of work would be made at different levels of management and Contractor is expected to ensure proper participation for effective reviewing and action plan.

2.18.8. The Contractor should ensure availability of professionally qualified planning engineer both at HO and site deemed adequate by the Owner/Engineer-in-Charge.

2.18.9. The Contractor at his own cost should maintain a control room at site highlighting all the features, schedule and achievements of the project.

2.18.10. Weighted percentage of each discipline/group of work shall be mutually agreed to between the Contractor and Owner/Engineer-in-Charge after the award of contract to facilitate compilation of progress.

3.0. CONSTRUCTION, CONSTRUCTION SUPERVISION AND MANAGEMENT

3.1. Construction

3.1.1. The Contractor will carry out the construction works in accordance with all relevant codes, standards, specifications, his documents and drawings, and based on the most efficient use of local resources. The Contractor will act as principal employer on the labour employed for construction activities and will follow Indian Labour Act, and all statutory regulations in this regard. The Contractor will have total responsibilities for the following:

- Construction, erection and installation of all equipment, machinery, piping and materials supplied by the Contractor.

- Site supervision, planning and coordination at site.

3.1.2. Major categories of construction work performed by the Contractor will comprise of but not limited to the following:

- Civil work: Aboveground structure work; refractory, brick and castable work.

- Civil foundation work shall be done by the bidder.

- Machinery: Installation of machinery and equipment; assembling of large size equipment, if any
The Contractor is required to organise and mobilise construction management services in a systematic and sequential manner to ensure that the plant installation is carried out in accordance with the approved engineering drawings, specifications, standards, QA/QC procedures etc. and its mechanical completion is achieved within targeted time schedule. For this purpose, the Contractor shall deploy a construction management team headed by a Resident Construction Manager (RCM) at site.

The construction management team shall include engineers/specialists in QA/QC, project control (planning, scheduling, monitoring), contracts, construction supervision, progress measurement/billing, safety, warehousing, purchasing etc.

Construction supervision, coordination and management activities shall be carried out by Contractor in accordance with the approved construction procedures by PMC. Contractor will prepare construction schedules based on the overall project schedule of the plant and submit to Owner/PMC for approval. Monitoring and control of the construction activities will be carried out as per the approved construction schedule and procedure.

A construction management team headed by a Resident Construction Manager will be deployed at site by Contractor. The Contractor shall ensure delegation of adequate and sufficient power to his RCM for effective and smooth functioning of the field management. HO support shall be provided to the RCM at site during construction as and when required on all matters of project execution including the following:

- Field engineering
• Vendor specialists required during construction

• Rectification/replacement of defective supplies, if any, noticed during construction

• Inspection/expediting of replacement orders/field purchase order for ordered items placed by field purchase

• Expediting replacement of imported items found short/damaged.

3.1.4. The Contractor shall establish and maintain a material testing laboratory for carrying on field tests during execution of contracts under different disciplines by Sub-contractors, at no extra cost to owner. Also, all material handling equipment shall be subjected by the Contractor to required load test initially and then periodically to ensure safe/stable operation including witnessing and maintaining records of such tests.

3.1.5. The construction organisation will include the following for effective execution, monitoring and control: planning, scheduling, monitoring reporting, construction supervision, quality assurance and quality control, warehouse management and material control, field engineering/purchase, safety personnel administration.

(a) Quality Assurance and Quality Control (QA/QC):
QA/QC personnel will be responsible for ensuring quality of construction carried out by different Sub-contractors in accordance with the approved QA/QC procedures and management of material testing laboratory.

(b) Warehouse Management and Material Control:
This discipline will be responsible for carrying out the warehouse management and material control in accordance with the warehousing procedure and material control procedure. The material control plan and warehousing procedure shall be Contractor for Owner/ PMC’s review/approval. The activities of the contractor will include:

• Transport Liaison, filing of insurance claims and follow up.

• Receipt, handling, identification, inspection, and acceptance of materials including free issue materials to be supplied by owner.

• Documentation for control and accounting of materials.

• Materials control and issue

• Inventory checks

• Field requisition and purchase

• Spare and tools
• Material appropriation and handing over

• Security

• Taking with suppliers on short supplied items and placing replacement orders for lost/damaged items.

• Intimating HO regarding short, lost, damaged items and taking up with suppliers and taking replacement action when applicable.

• Perform material reconciliation and identification of surplus material and its handing over to the Owner after certification by the PMC.

• Contractor will generate and issue following reports: fortnightly statement of consignments in transit; daily report of material received; report on over, short, reject, and damage receipts against each consignment on receipt at warehouse; weekly status of consignments, material receipt report; monthly status of field purchase; monthly status of excess, shortage rejected and damage settlement.

(c) Field Engineering:

This discipline will be responsible for controlling and issue of technical drawings and documents, preparation of field sketches, field modifications, checking/preparation of as-built drawings, technical assistance for field purchase and field tendering etc. Specialist engineers from Vendor HO will also be deployed at site as per requirements.

• Field tendering will be responsible for carrying out field tendering activities if required.

• Field purchase contractor will be responsible for carrying out field purchase activities if required. The bulk of procurement action will be done from HO. Field purchase items are restricted to those required for running and maintenance of the field offices, items required for field, items required to expedite construction work and items found short, missing or damaged against the main order when received at the site.

(d) Safety:

It is the responsibility of the Contractor to ensure that safe construction procedures are complied with. They will also ensure that adequate first aid medical facilities are available for emergency purpose and that safety procedures as per the approved safety procedure are followed by the different Contractors. To assist in the development of an effective safety programme, a safety checklist for various jobs shall be developed and the same shall be reviewed by the Contractors Site Incharge.
The responsibilities will include the following: coordination and supervision of the details of the job safety programme; initiation and supervision of the use of accident report and investigation form; preparation of periodic accident summaries; tallying safety inspection of the job site and submission of summary inspection report to site PMC in charge.

3.2. Quality Assurance/Quality Control

All work/services to be performed by the Contractor under this contract shall be of specified/approved quality and Contractor shall have a quality assurance/quality control (QA/QC) system during the performance of various activities such as engineering, procurement, tendering, construction etc. Review/approval of activities by Owner/PMC shall not however dilute the responsibility of Contractor for maintaining quality.

(a) QA/QC Procedure:
Contractor shall submit the QA/QC procedure to be adopted for engineering procurement and construction activities of plant for review and approval to Owner/PMC. The QA/QC procedure shall cover all activities to be performed by Contractor. Some important activities and procedures to be evolved are listed below:

- **General:**
  Document control, coordination, non-conformance report of Sub-contractors, output identification and traceability, QA system review

- **Procurement/Inspection:**
  Incoming material control, welding qualification and repair, manufacturing or fabrication process control, applicable non-destructive examination, coating/lining, preservation, post-weld heat treatment wherever applicable, packaging and despatch control, transportation, inspection/test plans for all specific and mandatory tests (as per drawings and codes) with clear indication of witness, verification and hold points.

- **Construction:**
  Pre-construction activities, job construction, welding qualification and repair, inspection/test plans for all specified tests (as per drawing and codes) with clear indication of witness, verification and hold points. Contractor shall prepare construction QA plans for review of the Owner/PMC and the same shall cover as minimum the areas as under, and shall confirm their compliance to approved codes/standards/specifications, etc.

- **Site Preparation:**
  Tie-ins, structures, incorporation of all witness tests/hold points of construction work, clean-up testing, instrumentation installation and construction.
(b) As a part of Construction and Quality Assurance, the Contractor shall also comply with the following activities:

- Stage-wise inspection of quality of work as per approved QA plan and contract specifications.
- Develop welding procedures and welders qualification procedures for their work.
- Ensure compliance of various statutory rules, regulations and safety measures and to arrange and co-ordinate site inspection, testing etc. as required under local statutory rules and regulations prevalent in India.
- Take all necessary precautions to protect construction work and material from damage by climate, outside elements and construction activities.
- Ensure that materials used are in accordance with drawings/project specification.
- Review safety procedures prepared by the Contractor for compliance with applicable codes, regulations and Owner requirements.
- Prepare schemes for heavy/critical equipment's erection/lifts/rigging before and submit the same for PMC review/approval.
- Ensure alignment (hot/cold) of all critical rotary equipment/machinery and their upkeep/maintenance as per suppliers’ recommendations.
- Perform housekeeping activities, which include maintaining sanitary facilities, sweeping clean up, removal of excess materials/temporary facilities, scaffolding, as necessary.
- Conduct periodic quality/technical audits for ensuring quality and conformance with the contract.
- To take immediate appropriate corrective actions as and when such discrepancy arises to fulfil quality, safety obligations.

(c) QA/QC procedure shall also include quality plans, mostly in tabular formats defining the specific quality practices and flow of every identifiable activity of a discipline. All disciplines concerned with the performance of work are to be covered. These quality plans should indicate the following:

- For Design and Engineering: Activity description; preparation, checking, review and approval requirements; code of conformance (applicable standard specification number); applicable procedure number; QA data/records produced.
• For Procurement and Construction: Activity description; procedure number, inspection and test plan number, conformance code, testing and inspection code

(d) QA/QC procedure and quality plans will be discussed during kick-off meeting. Hold, witness and verification points and Owner/PMC review/audit requirements will be finalised between Contractor and Owner/PMC.

(e) During the performance of the contract, the Contractor shall:

• Implement approved quality assurance programme including but not limited to:

  (i) Performance of internal quality audits, preparation of audit reports and submission for review of PMC. Contractor shall evolve a comprehensive system of planned and documented audit to verify whether various performed activities comply with detailed procedures, specifications, guidelines etc. and to determine the effectiveness of quality system. Scope of such internal audits shall be furnished to PMC for review. Verification documents shall be generated during audit and submitted periodically to PMC for review. Throughout all stages of the scope of contract, the Contractors procedures, documents, activities, products and services and those of his Sub-contractor's shall be subject to Owner/PMC review/approval. Such surveillance and audit are optional and shall not relieve the Contractor of his contractual obligations and liabilities.

(ii) Generation of QA records (mostly inspection and test plans) as per quality plan and submission for review by Owner/PMC. The Contractor shall submit all quality records (generated during activity execution) and audit results on well laid formats/performance for Owner/PMC review. The rights of such review are reserved by Owner/PMC. Owner/PMC may review it in full, parts or selectively. However, complete correctness of the QA records shall be the sole responsibility of the Contractor irrespective of its review by Owner/PMC.

• Facilitate Owner/PMC in the quality audit at works.

• Certify QA Programme documents of Contractors and submit to Owner/PMC for review.

• Carry out audits/inspection at Contractors works as per approved QA programme and submit the reports for review by Owner/PMC

• Get similar QA system implemented at his Sub-contractor's works/office. QA records from the Contractor shall be reviewed and certified for compliance by the Contractor before submitting to Owner/PMC for information.
• Carry out audits at Contractors’ office/works and submit the report to Owner/PMC for information.

• Ensure that all personnel shall be assigned tasks commensurate with their qualification. Specialized workmen shall be qualified and certified.

• Handle non-conformance brought out by internal and external sources as follows:

  (i) Non-conformance brought out by Contractor's own review/audit shall be resolved by Contractor himself. One level higher than those responsible to carry-out the activity shall resolve the non-conformance. Such resolution shall be in full knowledge of Departmental Manager. Corrective action shall be initiated at the earliest. Report of such resolution shall be submitted to Owner/PMC for information.

  (ii) Non-conformance brought out by Owner/PMC through any of the following shall be resolved by the Contractor. Such corrective actions shall be submitted to Owner/PMC for review. However, corrective action shall be initiated at the earliest for: technical reviews, QA review and surveillance, inspection, external audit (Owner / PMC)

3.3. Construction Equipment

The Contractor is required to organize and mobilize the construction equipment and other tools tackles in a sequential manner to ensure that plant installation is carried out in a mechanized manner and its mechanical completion is achieved within targeted time schedule. The Contractor shall without prejudice to his responsibility to execute and complete the work strictly as per the specifications and other laid down procedures by mechanizing the construction activities to the maximum extent by deploying all necessary construction equipment/machinery of adequate capacities and numbers. For this purpose, the Contractor shall deploy a rigging team headed by a rigging foreman reporting to Area Engineer responsible for equipment erection.

Area Engineer should be well conversant with various erection techniques and shall be responsible for preparing erection schemes in accordance with the approved procedures and based on crane manuals suiting to plan layout. Area Engineer will have to foresee various other constructive activities in the surroundings while planning erection schedules including safety aspects of man and machinery also.

Contractor will prepare erection schedule based on the overall project schedule of the plant in phased manner with erection schemes of various equipments, vessels and submit to Owner/PMC for approval, monitoring and control of erection schedule. Erection activities will be carried out as per the approved construction procedures.
For efficient working and maintenance of construction aids, Contractor shall establish and maintain crane yard/workshop equipped with regular maintenance facility for various construction aids for carrying out routine field maintenance during performance for the contract. Temporary approach road, wherever required for the movement of the crane and other vehicles for equipment erection and transportation of material shall be properly planned and be made by the Contractor for quick mobilisation of the transportation system. The proper padding for the crane movement shall be done to avoid any delays of erection schedule. Weekly/fortnightly maintenances shall be planned in such a way that it should not hamper the erection schedule.

Contractor shall ensure the timely augmentation of the plant, equipment and machinery depend upon the exigencies of the requirement to meet the overall project schedule. During performances of the work, Contractor must ensure that structures, materials or equipments are adequately braced by guys, struts or otherwise approved means which shall be supplied and installed by the Contractor as required till the erection works is satisfactorily completed. Such guys, shoring, bracing, strutting, planking supports etc. shall not interfere with the work of other agencies and shall not damage or cause distortion to other works executed by him or other agencies. Contractor to submit the construction equipment schedule along with the bid.

3.4. Construction Manpower

The Contractor is required to organise and mobilise construction staff in a sequential manner to ensure that plant installation is carried out in accordance with the S curve defined with other chapter of the Bid package. Mobilisation of construction staff should be such that ‘S’ curve based on the time schedule and progress achieved in the phased manner should match with the overall project time schedule. For this purpose, the Contractor shall clearly indicate in his construction methodology that work shall be done departmentally or by engaging such Sub-contractor or the combination of both.

Contractor will prepare detailed methodology for the work to be carried out departmental as well as by Sub-contractor clearly defining the scope and responsibility of main Contractor and Sub-contractor.

In case, Contractor proposes to engage Sub-contractor for the erection of various activities, he must enter into an agreement of Memorandum of Understanding and same shall be furnished along with their credential with the bid. Sub-contractor’s credential will be evaluated along with the offer. Contractor shall not be permitted to change the Sub-contractor after the award of work under any circumstances. Non-compliances of the above will be strictly dealt with relevant provisions of the contract.

During the execution of works at site, if the principal Contractor engages Sub-contractors for execution of works at site as per approval obtained from Owner/PMC in line with contract provisions and in the event Sub-contractor complains in writing to the Owner with regard to the non-payment of their dues from the principal contractor for the works
executed by them and site (excluding final payments and payments due after termination of Sub-contractors' services by the main contractor), Owner reserves their right to make such payment to the Sub-contractors based on approved measurement with due notice to the principal Contractor. Owner shall release such payments to Sub-contractor at the cost and risk of the main Contractor in order to ensure smart execution of work at site.

The above such payment made by Owner to the Sub-contractor shall be adjusted in the running account bills or any other payment due to the concerned principal contractor. Contractor to submit the construction manpower schedule.

All Sub-contractors will be managed by the main Contractor construction staff who will perform the duties of construction management and will administer, coordinate, and inspect the work of the Sub-contractor and be responsible for the quality.

The contractor will establish the prerequisite for successful construction of sub-contractor work. However, by deploying the Sub-contractors as approved by Owner/PMC for any discipline, does not absolve the principal Contractor for his total responsibility under the subject contract.

The Contractor to ensure that in case of Sub-contract failure to execute the works as per standards/specifications/drawings and negligence and disobedience in carrying out any order or instruction of Owner / PMC will be viewed very seriously and dealt with appropriately in accordance with provisions of the contract. Contractor to submit the construction manpower schedule along with the bid.

4.0. QA SYSTEM / INSPECTION REQUIREMENTS FOR BOUGHT OUT ITEMS & DURING CONSTRUCTION

4.1. General

Contractors are required to follow a well-documented quality assurance and quality control system covering all phases of project viz. engineering, procurement, installation, testing and commissioning. Similarly, Contractors are required to develop their own resources for inspection of all bought-out items supported by third party inspection services for specific cases. Supervision of construction activities is the responsibility of turnkey contractor; Owner/PMC role during construction phase is for quality surveillance.

4.2. Specification for Turn-Key Bidder's Quality Assurance System

(a) Introduction

This specification establishes the quality assurance requirements to be met by the turnkey bidder during execution of contracted services. In case of any conflict between the requirements of this specification and other documents such as technical specifications,
contract conditions etc., the contractor shall notify Owner/PMC of all such conflicts for final resolution.

(b) **Scope of Work by Contractor**

Prior to the award of contract, the following documents shall be submitted along with the bid for evaluation:

- Quality policy
- Quality objective
- Company quality manual
- Project quality plans
- Copy of certificate of approval of quality management system

After the award of contract, within four weeks after the award of the contract, the Contractor shall participate in the pre-start meeting with Owner/PMC to finalize ‘Project Quality Plans’ as regards to the following:

- Standard practices specified by the Contractor
- Hold, witness and verification point
- Owner/PMC’s review/audit requirements

During job execution, implement approved project quality plan including but not limited to:

- Performance of internal quality audits, preparation of audit reports and submission for Owner/PMC’s review.
- Generation of QA records as per quality plan and submission for Owner/PMC’s review.
  - Records of management review of quality system
  - Contract review records
  - Design review, verification and validator’s records
  - Assessment records of acceptable vendors/sub-vendors
  - Records of nonconformity
  - Records of external quality audit
  - Records of training
  - Inspection reports
  - Test data/inspection and test plans
  - Qualification reports
  - Material review reports
- Calibration data
- Quality cost report
- Schedule control and progress reports

- Facilitate Owner/PMC in the quality audit at his works.
- Certify QA Programme documents of sub-contractor and submission for review to Owner/PMC.
- Carry out audits/inspection at sub-contractor's works as per approved QA programme and submit the reports for Owner/PMC's review.

(c) Quality Assurance System Requirement

- Requirements stipulated in this specification shall be fulfilled by the Contractor/Sub-contractor. All other features of QA System shall be as per Contractor’s standards.

- The Contractor shall ensure that the quality system is clearly understood and faithfully implemented at all levels in his organisation.

- The Contractor shall develop quality consciousness’ among all personnel working for the contract.

- Non-conformances brought out by Contractors/Sub-contractors’ own internal review/audit shall be resolved by Contractors’/Sub-contractors, themselves. One level higher than those responsible to carry out the activity shall resolve the non-conformances. Such resolution shall be in full knowledge of Departmental Manager. Corrective action shall be initiated at the earliest. Report of such resolution shall be submitted to Owner/PMC for information.

- Non-conformances brought out by Owner/PMC through any of the following: technical reviews, QA reviews and surveillance, inspection, external audit (Owner/PMC), post construction quality audit (by Owner/PMC) to be carried out immediately after declaration of mechanical completion by the Contractor. Non-conformances brought out due to the above, shall be resolved by the Contractor/Sub-contractor. Such corrective actions shall be submitted to Owner/PMC for review. However, corrective action shall be initiated at the earliest.

- The Contractor shall evolve a comprehensive system of planned and documented audit to verify whether various performed activities comply with detailed procedures, specifications, guidelines etc. and to determine the effectiveness of quality system. Scope of such internal audits shall be furnished to Owner/PMC for review. Verifiable documents shall be generated during audit and submitted periodically to Owner/PMC for review. Audits shall be carried out by independent engineers not responsible for execution of the activity to be audited.
• Throughout all stages of the scope of contract, the Contractor's procedures, documents, activities, products and services and those of his Sub-contractors' shall be subjected to quality surveillance and audit by Owner/PMC. Such surveillance and audit are optional and shall not relieve the Contractor of his contractual obligations and liabilities.

• The Contractor shall submit all quality records (generated during activity execution) and audit results on well laid formats/proforma for Owner/PMC's review. The rights of such review are reserved by Owner/PMC. Owner/PMC may review it in full, parts or selectively. However, completeness correctness of the QA records shall be the sole responsibility of the Contractor irrespective of its review by Owner/PMC.

• The Contractor shall get similar QA system implemented at his Subcontractors’ works/office. QA records from the Subcontractor shall be reviewed and certified for compliance by the Contractor before submitting to Owner/PMC for information.

• Contractor shall carry out audits at Subcontractors, office/works and shall submit the report to Owner/PMC for information.

• All personnel shall be assigned tasks commensurate with their qualification. Specialized operators shall be qualified and certified. The Contractor shall have a system for identifying personnel training needs in line with the latest ISO guidelines.

• Immediately after submitting written declaration of mechanical completion by the Contractor, Owner/PMC will carry out post-construction quality audit. Contractor shall extend all help and cooperation to carry out this audit including providing all necessary resources to Owner/PMC and shall implement all corrective measures, based on the post-construction quality audit findings and observations at no cost to the Owner/PMC.

• A pre-startup safety review (PSSR) checklist is a tool used by a PSSR team during a safety review of a new facility before commissioning. This checklist helps ensure that a facility will be safe for employees and that equipment will operate according to design specifications. This may be added here to ensure safety aspect before pre-commissioning. All the points in the PSSR has to be complied by LSTK contractor before start up of the unit.

4.3. Inspection Coordination Methodology for Turnkey Package

4.3.1. All equipment and materials are to be procured from vendors listed in the approved Vendor List enclosed in this Bid, or from other reputed vendors after obtaining specific approval of the Owner/PMC. In this regard, no difference is made between the equipment and materials purchased by the contractor directly or by his contracted agencies.

4.3.2. After finalisation of purchase order, a detailed QA/QC plan shall be developed by the vendor, duly reviewed by the Contractor and shall be submitted for approval of the
Owner/PMC. It is envisaged that QA/QC plans for the critical items shall be reviewed/approved by the Owner/PMC and for the balance items QA/QC plans shall be submitted for records. The management of quality control system is to be developed generally based on the categorisation of various equipment and materials. Preliminary categorisation of various items involved is enclosed. For items not included here, categorisation shall be decided during detailed engineering and Owner/PMC may change inspection category based on final information and quantities. For indigenous items, Contractor shall employ an approved third party inspection agency to carry out inspection on his behalf, whose involvement must be brought out in the detailed QA/QC plans. For imported items, contractor should engage Owner/PMC approved Third Party Inspector (TPI). Each stage of inspection by the TPI, must define whether it is a hold point, witness point, verification point or internal inspection point by the vendor. Contractor shall make independent QA Plans through the approved Third Party Agency which shall be having a confirmation of meeting the minimum inspection requirements spelt out. All inspection stages where Owner/PMC desires to participate (which shall be preferably only for critical items) shall be marked on the QA/QC plan and these stages must necessarily be attended by the Contractor in addition to the other stages being attended by him. In case the QA/QC plans are not submitted in sufficient detail, the Contractor may be asked to re-submit the plans.

4.3.3. The personnel to be deployed by the third party inspection agency must have adequate qualification and experience for the type of work involved and the owner may ask for approval of the personnel employed for the job and his replacement, if required.

4.3.4. The Contractor shall submit a detailed vendor's inspection schedule for the coming two months at the beginning of each month as well as notify owner's involvement at the appropriate inspection stage, giving a clear notice period of 15 days. The contractor shall submit monthly inspection and expediting reports of the inspection agency regularly to the Owner/PMC.

4.3.5. PMC's inspector shall witness the test on a mutually agreed date according to contractor's inspection notification, wherever applicable.

4.3.6. Submission of category-wise inspection plan by Contractor at PMC HO for review. It is envisaged that the QA/QC plans shall be submitted to the PMC in accordance with the clauses as defined above.

4.3.7. After finalisation of the vendor, the copy of PO or technical specification for sub-ordered items along with QAP will be submitted by Contractor to PMC covering the location where the sub-ordered items are manufactured. The QAP is to be duly approved by the PMC.

4.3.8. Contractor will be totally responsible for furnishing the complete and correct technical document/specifications to his sub-vendor. It is responsibility of the contractor to ensure that relevant specifications indicated in the tender documents are incorporated in the sub-
order/sub-order specification. Each PO shall categorically indicate involvement of various agencies for inspection.

4.3.9. Contractor shall forward the approved copy of relevant drawings/documents to the TPI before giving inspection call. The final inspection will be done by the TPI, based upon drawings/documents reviewed by TPI/PMC in Code ‘AP’ (Approved) wherever applicable.

4.3.10. Contractor will ensure presence of their inspection engineer at sub-vendor's works during inspection by TPI or Owner/PMC inspection engineer (wherever applicable).

4.3.11. Contractor shall expedite to ensure delivery of all the materials as per CDD.

4.3.12. All correspondence by contractor to the PMC for submission of documents and inspection calls shall also be intimated to Owner.
SECTION – VI - 7.0

CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP

PLANT: STEAM GENERATION PLANT

PROJECT: INTEGRATED COAL BASED FERTILISER COMPLEX AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA)
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1 General scope of Work and services - Construction/Erection

LSTK CONTRACTOR shall be responsible for construction and erection of the Plant/Unit including but not limited to the following:

1.1 Construction and erection of Plant/Unit and perform all other activities required to be performed for implementation of the WORK.

1.2 Provide and supply in due course all construction Equipment and Materials, tools, and temporary facilities necessary for implementation of the WORK.

1.3 Establish and operate adequate material control system in site for receipt, unloading, inspection, maintenance, handling, storage and utilization to ensure all Equipment and Materials are preserved and available as necessary for completion of the Plant/Unit.

1.4 Provide and supply all staff, tradesmen and labours for implementation of the WORK.

1.5 Establishment of overall construction policy and procedures for the Plant/Unit.

1.6 Provision of overall management and control of construction phase of the Plant/Unit.

1.7 Ensuring that all parts of the Plant/Unit are constructed and tested strictly in accordance with the specifications and applicable codes and standards asked for in the project documents.

1.8 Ensuring that construction is accomplished in accordance with the schedules.

1.9 Provide transportation of all Equipment and Materials to be provided and supplied by LSTK CONTRACTOR under the CONTRACT either from inside or outside to Site.

1.10 Construct, operate and maintain all temporary facilities required for its personnel involved in the WORK.

1.11 Provide transportation in the area of the Site and between Site and temporary facilities for all its personnel involved in the implementation of the WORK, including field labour, administrative staff, etc.

1.12 Recruit field and organize, manage and supervise its Sub Contractors and field labour for the WORK.

1.13 Provide liaison with OWNER, Sub Contractors, Licensors and Vendors to ensure that the Plant/Unit is constructed in accordance with the respective standard and specifications, set forth in the CONTRACT.
1.14 Establish with OWNER adequate procedures, control and reporting systems to provide close control of the progress of the WORK.

1.15 Provision of labour and facilities for loading, unloading and transportation of the Equipment within the site area.

1.16 Performance and/or provision of all other works and/or services required for performance of the WORK.

1.17 Execution of the whole civil, structural and building works of the Plant/Unit and/or utilities and off-site facilities.

1.18 Prefabrication of piping spools in a shop on the Site.

1.19 Erection and installation of EQUIPMENT and auxiliary facilities associated with the Plant/Unit.

1.20 Erection and field fabrication of structural steelwork, cladding ladders, handrails, stairs and platform of the Plant/Unit and/or utilities and off-site facilities.

1.21 Installation of pipe work including field fabrication at site.

1.22 Installation and testing of all instrumentation network and equipment of the Plant/Unit.

1.23 Installation and testing of electrical system and equipment of the Plant/Unit.

1.24 Installation of rubber lining, refractory brick lining & C-Brick lining, FRP/PVC/HDPE lining, as required for the Plant/Unit.

1.25 Painting of steelworks, piping, Equipment and building of the Plant/Unit.

1.26 Maintenance of construction equipment, vehicles and tackles of the Plant/Unit, during construction and erection period.

1.27 Pre-commissioning, Commissioning and Start-up of the Plant/Unit.

1.28 Carrying out Mechanical Completion.

1.29 Perform all material identification as per application codes and standards.

1.30 Provide winterization during construction.

1.31 Provide drawings and documents as required.

1.32 Supply to OWNER complete test records within three (3) days after completion of actual testing.

1.33 Installation and testing of all underground piping, if any.
2.0 General scope of WORK and Services- Pre-commissioning

LSTK CONTRACTOR shall be responsible for the pre-commissioning phase of the Plant.

LSTK CONTRACTOR shall provide at SITE an adequate number of qualified pre-commissioning engineers to direct and control pre-commissioning activities.

LSTK CONTRACTOR shall also ensure that all special tools and test equipment required for pre-commissioning are available at its own cost.

LSTK CONTRACTOR shall provide adequate construction labour, construction tools and equipment for pre-commissioning.

Pre-commissioning which shall be performed by LSTK CONTRACTOR shall include, but not limited to the following:

2.1 Cleaning, flushing, draining blowing out, steaming out, drying and purging of Equipment and their linings and piping systems, including the installation and removal of temporary blinds, strainers, screens etc., and the replacement of all permanent items removed while the WORK is in progress.

2.2 Chemical cleaning wherever required, including but not limited to compressor suction piping and lube and seal oil piping, heaters, supply of chemical and disposal of wastes.

2.3 Chemical cleaning of feed water systems, and steam systems. Supply of chemical and disposal of wastes.

2.4 Chemical cleaning of any other parts, which have corroded to an extent, which, will detrimentally affect Plant/Unit performance or run length for such reasons as increased fouling due to rust. Supply of chemical and disposal of wastes.

2.5 Checking, Testing, calibration simulation test and adjustment of instruments, equipment and systems including control valves and safety devices, and installation and checking of orifices plates and other sensor devices in so far as this can be done before actual operation of the item concerns of complete system and loops.

2.6 Function test and checking out of electrical systems including substations, transformers, cables and switchgear, checking of all interlocks and setting of all relays. This shall include drying out operations, filtering of oil if required.

2.7 For motor driven equipment, amperage checking of motors and removal of temporary safety screens.
2.8 Cleaning of screens and filters replacement and adjustment of packing and seals and tightening of flanges.

2.9 Introduction of fuels.

2.10 Introduction of lubricants and oil flushing for machinery.

2.11 Introduction of chemical into and initial operation of treatment plant.

2.12 Boiling out, bringing up to pressure and performing all required code tests on steam generation facilities and associated instrumentation.

2.13 Drying out of stacks and all refractory lined equipment.

2.14 For all piping systems, installation and removal of temporary blinds as required, circulation and commissioning of systems including process systems, services, effluent and drainage, utilities distribution, relief and blow down and interconnecting lines.

2.15 Test running of all other rotating equipment for 24 hours wherever possible.

2.16 Adjustment of all piping expansion and support devices.

2.17 Air-drying of Plant/Unit, which is required to be water-free.

2.18 Testing (including running, tightness and vacuum) of systems, as necessary to ensure that the sections and components of Plant/Unit are ready for operation.

2.19 All such further works which LSTK CONTRACTOR judges to be necessary or in the reasonable opinion of OWNER is necessary to bring the Plant/Unit to a state of readiness for the introduction of feedstock into Process Plant/Unit for processing requirements and for safe commencement of operation.

3.0 Basic Plan For Temporary Services

Temporary Construction Facilities
The LSTK shall arrange following facilities at his own cost for Construction/Erection purpose. Demolition and cleaning of temporary facilities developed for construction purpose shall also be under LSTK Contractor’s scope.

1. 1 No. 11 kV Feeder (rated for 2 MVA) at Existing Substation near 132 KV Switchyard shall be made available. Tapping of Construction Power (on chargeable basis) from this feeder (including supply & erection of all required materials like structural supports for cable tray, cable trays, power cables, control cables, protection & metering, cable termination etc. as well as underground cabling work) and further distribution shall be in LSTK Contractor’s scope.

2. Construction Water (on chargeable basis) shall be made available

3. Construction sheds

4. Construction offices

5. Temporary Communication facilities
6. Office furniture
7. Labour colony during construction.

3.1 Sewage & Refuse Disposal

All temporary building like site office, canteen etc. shall be provided with individual septic tanks and soak pits for treatment and disposal of sanitary sewers. Construction site shall be provided with a network of temporary drain for disposal of rain water.

4.0 Mechanical Completion

Mechanical Completion means the time when all construction, erection & installation work per finally approved P&ID after HAZOP study and pre-commissioning related to the Plant is completed in accordance with the Project drawings and specifications, and all mechanical and pressure tests, including but not limited to hydro-testing, non-operating adjustments, cold alignment checks, final cleanup, hot bolting, refractory drying, field calibration of safety valves, calibration of all instruments, instrument loop checking and testing, monitoring / control / safety systems checking and testing, and all pre-commissioning activities have been completed, all incoming & outgoing services and utilities have been connected to each unit of the PLANT, interconnections of process lines and interconnection are completed and the Plant/Unit is ready in every respect for commissioning and for the first introduction of feed materials.

When OWNER is satisfied that Mechanical Completion of the plant has been achieved, OWNER shall issue certificate of Mechanical Completion to OWNER in accordance with the CONTRACT for Owner's Approval.

In order to meet this, LSTK CONTRACTOR shall perform all necessary mechanical works, tests and checks.

5.0 COMMISSIONING

5.1 Schedule for Commissioning

LSTK CONTRACTOR shall prepare a schedule for commissioning, start-up, and performance testing and initial operation in conjunction with OWNER. This shall be issued at least three months before pre commissioning of the first facility.

This schedule shall include all activities as detailed herein and any other special activities, which require to be performed during commissioning.

5.2 Commissioning

LSTK CONTRACTOR shall be responsible to perform commissioning of the Plants and to provide necessary facilities during commissioning of the Plant including the Performance Tests. LSTK CONTRACTOR shall provide commissioning engineers and supporting staff and adequate commissioning labour. LSTK Contractor shall associate OWNER’s engineers and operating staff with the commissioning work.
6.0 START UP

LSTK CONTRACTOR shall be responsible to perform start-up of the Plant/Unit. LSTK CONTRACTOR shall provide necessary facilities and for Start Up of the PLANT.

NOTE:
Detail CONTRACTOR’S scope of work in relation with the construction / erection, and pre-commissioning, commissioning and start-up from the point of scope of execution as well as performing way are described in detail in the following Sub-Annexes of Section-7.0.
Sub-Annexures:

Annex 7 - 1 : LSTK Contractor’s Work Definition

Annex 7 - 2 : Detail Technical Scope

Annex 7 - 3 : Quality Control Procedures and Inspection Requirement

Annex 7 - 4 : Schedule Progress Evaluation and Progress Reporting

Annex 7 - 5 : General Notes
LSTK CONTRACTOR'S WORK DEFINITION

LSTK CONTRACTOR shall perform/provide the following activities but not limited to:

1. LSTK CONTRACTOR scope of work shall broadly consist of construction / erection, refurbishing, pre-commissioning, commissioning and Start Up of the Plant under the management of commissioning team it includes but not limited to civil works, fabrication & erection of structural steelwork, field assembly, mechanical erection and / or assembly and installation of all equipment and machinery, piping, electrical systems and network, instrumentation, insulation, painting, etc., except in so far as "Contract" otherwise provides, the provision of all temporary facilities, staff, tradesmen, labour, tools, tackle, construction equipment and materials, insurance, consumables and everything whether of temporary or permanent nature necessary and required in and for the work, so far as the necessity for providing the same is specified or reasonably inferred in or from the contract.

2. Perform all civil and building works as per Annex 7 - 2A, titled civil and building works.

3. Perform all structural steel works as per Annex 7 - 2B, titled structural steelwork.

4. Perform all piping fabrication and erection works as per Annex 7 - 2C, titled piping fabrication and erection work.

5. Perform all equipment erection works as per Annex 7 - 2D, titled equipment erection work.

6. Perform all electrical works as per Annex 7 - 2E, titled electrical work.

7. Perform all instrumentation works as per Annex 7 - 2F, titled instrumentation works.

8. Perform all insulation works as per Annex 7 - 2G, titled insulation works.

9. Perform all painting works as per Annex 7 - 2H, titled painting Specification/work.

Supply the materials in order to execute WORK as per CONTRACT.

10. LSTK CONTRACTOR shall be responsible for providing services and materials for construction of all temporary facilities, which are essential for successful completion of construction and erection.

The LSTK CONTRACTOR shall establish, operate and maintain all temporary facilities, such as, but not limited to:
a) Labour camp/officers camps

b) Fabrication shops/yard

c) Workshop for maintenance of construction/testing equipment.

d) Field drawing office

e) Temporary warehouses, including open storage yards.

f) Construction offices (including facilities for photocopying, drawing reproduction, etc.)

g) First aid along with ambulance

h) Lab facilities, including NDT, for testing calibration, etc.

i) All temporary or approach roads for carrying out the WORK including temporary approach roads for access to LSTK CONTRACTOR’S site office/workshop/camp, etc. ground preparation for heavy lifts including approaches to cranes for heavy lifts. OWNER does not take any responsibility for making temporary roads.

j) Canteen & catering facilities for all LSTK CONTRACTOR’S work force.

k) All drainage around the facilities created for his WORK, and sewage disposal arrangements for labour camps/officers camps, site offices, etc.

l) Necessary transport for movement of its personnel, construction Equipment and Materials, consumables, etc.

m) Watering of roads through water tankers for dust suppression.

o) All temporary lighting for working during night.

p) All temporary hutments, sanitary & potable water and domestic sewerage requirements of LSTK Contractor’s work force.

11. Supply to OWNER complete survey report within three (3) working days after completion of any survey.

12. All excess soil shall be disposed of by LSTK CONTRACTOR outside the premises in a location designated by OWNER representative.

13. Perform all nondestructive, hydrostatic and precommissioning testing required.

14. Supply to OWNER complete test records within three (3) days after completion of actual
15. Perform all welding including radiography required.

16. Provide drawings and documents as required.

17. Provide mobilization and demobilization, temporary material and temporary facilities and utilities required executing work.

18. Provide winterization during construction.

19. Provide scheduling, planning and reporting as per CONTRACT.

20. Keep complete administration and control of work, specified in CONTRACT.

21. Provide maintenance on all construction and permanent plant material as required during the CONTRACT period.

22. Perform all material identifications as per CONTRACT.

23. Perform all transportations as required.

24. Perform quality assurance, control and supply quality control documentation.

25. Perform all pre-commissioning activities as defined in the CONTRACT.

26. Provide and supply all procedures for execution of the work in accordance with drawings specifications, and applicable codes and standards.

27. Perform all other works and activities and supply all other materials which are required for completeness of the Work either mentioned in the CONTRACT or they are necessary for completeness of the work, in compliance with highest available standards and good quality.
ANNEXURE- 7 - 2

DETAIL TECHNICAL SCOPE

See accompanying by discipline

Annexure-7 - 2A  Civil and Building work
Annexure-7 - 2B  Structural steel work
Annexure-7 - 2C  Pipe prefabrication and Erection
Annexure-7 - 2D  Equipment erection
Annexure-7 - 2E  Electrical work
Annexure-7 - 2F  Instrumentation work
Annexure-7 - 2G  Insulation work
Annexure-7 - 2H  Painting work (For detail refer TS-2001)
ANNEXURE- 7 - 2A

CIVIL AND BUILDING WORK

1.0 SURVEYING

1.1 Base line and base elevation will be furnished to LSTK CONTRACTOR. LSTK CONTRACTOR will furnish all surveys from this base line and elevation.

1.2 OWNER shall have the authority at anytime to determine, in accordance with the drawings or written directives, the correctness on completeness of the lines in use by LSTK CONTRACTOR.

1.3 Any erroneous WORK shall be corrected to OWNER’S satisfaction at LSTK CONTRACTOR’S expense.

2.0 SITE

Finish grading elevation to be as shown on drawing. LSTK CONTRACTOR’S access to the WORK areas shall be via existing roads. Any other roads required by LSTK CONTRACTOR are to be developed by LSTK CONTRACTOR.

3.0 EXCAVATION AND BACKFILL

3.1 Excavation

- Provide all excavation by machine or by hand according to the specifications.

- Excavation is to be executed by LSTK CONTRACTOR in a manner that will provide adequate space for performance, inspection and timely completion of the WORK. Supply dewatering as required. The method of dewatering shall be subject to Approval by OWNER.

- Temporary water drainage routing requires prior Approval by OWNER.

3.2 Backfill

All backfills shall be according to the specifications.

All excavations shall be kept dry and workable prior to and during backfiring and compacting.

Material that LSTK CONTRACTOR excavates in the course of WORK and which can be used for backfill, must be approved by OWNER prior to use. All other backfill material as required in this scope of work, drawings and specifications, shall be supplied by LSTK CONTRACTOR.

Back filling shall be to ground level as shown on drawing. The placing of backfill may only
start after approval by OWNER.

LSTK CONTRACTOR will inform OWNER to arrange for the required proctor tests. Tests shall be done by OWNER on his account.

4.0 PILES AND CONCRETE FOUNDATIONS

4.1 Install Piles and major and minor concrete foundations in accordance with the specification and drawings.

4.2 Blinding to Underside Foundation Work

Prior to placing a blinding layer of concrete, LSTK CONTRACTOR shall supply, place, compact and prepare the surface of excavated area. After this LSTK CONTRACTOR shall supply a blinding layer of concrete. Blinding layer to be in accordance with specifications and drawings.

4.3 Reinforcement of Concrete

Cut and bend to bar bending schedules, all type of reinforcing bars.

Store and protect all reinforcing bars against corrosion and any other deleterious effects prior to placing.

Installation of reinforcement including installation of spacers, supports, tying, wire in accordance with the specifications and drawings.

4.4 Anchor Bolts

Install all anchor bolts, in accordance with the specifications and drawings.

The following WORK is included but not limited to LSTK CONTRACTOR’S scope for installation of anchor bolts:

- Deliver of all templates.
- Store and protect against corrosion and any other deleterious effects.
- Place anchor bolts accurately in formwork or by templates, if required, or in pockets.
- Clean and grease anchor bolts threads after Concrete pour and protect bolts after greasing with plastic covers.

4.5 Inserted and Embedded Item

Install all concrete inserts and embedded items, including but not limited to the following items in accordance with the specifications and to the detail drawings to be furnished by LSTK CONTRACTOR:

- Cement - In sockets.
- Cinch anchors.
- Steel sleeves, various size angle.
- Channel shapes with anchors. Curb angles and steel plates.
- Anchor rails.
- Pipe sleeves of heavy duty PVC pipe.

The WORK shall include but not limited to:

Store and protect against corrosion and damage placed accurately in Formwork or by templates, if required, or by temporary bars for proper positioning.

4.6 The following WORK is included but not limited to LSTK CONTRACTOR’S scope for installation of major and minor foundations:

- All excavation, including sheet piling, if required, backfill, compacting and the transportation of surplus material, neatly stockpiled at a location, chosen by LSTK CONTRACTOR and approved by OWNER. The supply, installation and maintenance of a complete concrete batch plant, including concrete testing laboratory. Installation of selected backfill material, if required. Supply and delivery and installation of all formwork, assembly and disassembly of all reusable formwork, inclusive if any and all required supporting, bracing, pockets, cutouts, recesses, etc.

- Bending and installation of concrete reinforcement bars to the requirements and supply of items as defined in 4.3 above.

- Installation of all anchor bolts (including fabrication of templates), to the requirements and supply of items as defined in 4.4 above.

- Installation of embedded and inserted items, to the requirements and supply of items as defined in 4.5 above.

- Installation of construction and expansion joints where required.

- Mixing, delivery and pouring of concrete in accordance with specifications. Stripping of formwork and removal of all surplus material to LSTK CONTRACTOR'S yard or locations designated by OWNER.

- All temporary storage of formwork at SITE shall be of an orderly nature. In case storage does not comply with the above-mentioned rule, OWNER shall have the right to remove formwork from SITE within forty eight (48) hours after first warning and back charge LSTK CONTRACTOR for all related costs. OWNER shall not be held responsible for any of LSTK CONTRACTOR’S losses.

- The finishing of concrete, where required to a finish in compliance with the specifications.

A copy of all-concrete mix truck delivery slips if applicable.
Concrete composition analysis of the concrete batch plant.

All scaffolding required.

All required dewatering to keep the excavations / backfill dry for the WORK.

5.0 CONCRETE STRUCTURES AND ELEVATED SLABS

Install concrete structures, in accordance with the specifications and drawings.

6.0 The following work is included but not limited to LSTK CONTRACTOR’S scope for installation of concrete elevated slabs:

See 4.6; however with -following exceptions: No-excavation, no backfill and- no dewater

7.0 YARD PAVING AND FINAL SURFACING

7.1 Excavation

Setting out and grading by machine and/or by hand for yard paving to the shape and depth in accordance with the specifications and drawings.

Disposal of all excavated material and neatly stock piling to a location chosen by LSTK CONTRACTOR and approved by OWNER.

7.2 Concrete Yard Paving

- Mix and install concrete for heavy duty paving areas, in accordance with the specifications and drawings.

- Mix and install concrete for light and medium duty paving areas in accordance with the specifications and drawings.

- The following work is included but not limited to LSTK CONTRACTORS scope for installation of concrete yard paving: See 4.6 above

- Surface preparation, including the supply and placing of waterproof building paper or similar waterproof material, well lapped at joints, laid on top of the well compacted sand layer and before pouring concrete.

- Reinforcement for heavy duty paving at top and bottom face and for light duty paving at top face only, with square mesh fabric reinforcement including protection against corrosion, the cutting, the bending and placement.

- Mixing and pouring of concrete in accordance with specifications, sufficient vibrating. Stopping clear from bases, plinths and piers and forming around surface and lay to give levels and falls.

- Installation of construction / expansion joints.
7.3 Unpaved Areas

Install gravel, tiles or crushed stone on leveled unpaved areas, all in accordance with the specifications and drawings.

7.4 Concrete Tiles for Walkways

Install well compacted sub-base layer and install the tiles on the sub-base all in accordance with specifications and drawings.

8.0 CONCRETE PIPE SLEEPERS

Fabricate and install reinforced concrete sleepers for pipe, complete with foundations in accordance with the specifications and drawings.

9.0 MANHOLES AND CATCH BASINS, TRENCHES

9.1 Fabricate and install pre-cast or formed and poured in situ concrete manholes and catch basins and trenches in accordance with the specifications and drawings.

9.2 The following work is included but not limited to LSTK CONTRACTOR’S scope for installation of manholes and catch basins. All excavation including sheet piling of required, backfill, compacting and the transportation of surplus material, neatly stockpiled at a location, designated by LSTK CONTRACTOR and approved by OWNER.

For Poured in Site

- Delivery and installation of all formwork, inclusive if any and all required supporting, bracings, pockets, cutouts recesses etc.
- Bending and installation of concrete reinforcement bars to the requirements and supply of items as defined in 4.3 above.
- Fabrication and installation of embedded and inserted items, if any, to the requirements and supply of items as defined in 4.5 above.
- Mixing and pouring of concrete in accordance with specifications.
- Stripping of formwork and removal of all surplus material to LSTK CONTRACTOR'S yard or locations designated by OWNER.
- All required dewatering to keep the excavations / backfill dry for installation work.
- Install cast - iron manhole frames and solid cover and fabricate and install steelwork catch basin grating and frames in accordance with specifications.

10.0 COLLECTION BASINS, PITS, SUMPS, RETAINING WALLS AND CULVERTS

10.1 Fabricate and install concrete collecting basins in accordance with the specifications and drawings.

10.2 Fabricate and install concrete sumps and pits in accordance with the specifications and drawings.
10.3 Fabricate and install concrete walls around tanks and other retaining walls in accordance with the specifications and drawings.

10.4 Fabricate and install concrete pipe and bridge culverts including head walls in accordance with the specifications and drawings.

11.0 DITCHES AND TRENCHES

11.1 Fabricate and install earthen and concrete ditches and trenches including connection pipes and boxes in accordance with the specifications and drawings.

12.0 STEEL SLIDING PLATES AND PTFE SLIDING PLATES

12.1 Steel Sliding Plates

- Fabricate and install steel sliding plates in accordance with specifications and drawings.

- The following work is included, but not limited to LSTK CONTRACTOR'S scope for fabrication and installation of steel sliding plates:
  - Pick up materials, storage and protection against corrosion and any other deleterious effects.
  - Fabricate, place in pockets, level and grout, protect against possible damage and corrosion.

12.2 PTFE Sliding Plates

- Install sliding plates, in accordance with the specification and drawings.

The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of sliding plates pick up materials, transport, store and protect:

- Place in pockets, level and grout, protect against possible damage.

13.0 GROUTING

13.1 Mix and install grouting in accordance with the specifications and drawings.

13.2 LSTK CONTRACTOR shall grout under all structural steel columns and under all equipments, as specified.

13.3 The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of grouting:

- Prepare top surface of base and/or plinth, pockets, sleeves etc., prior to placing grout.

- Mix and install grout mortar in accordance with specifications.
- Grout mortar shall be used between steel base plate and concrete foundations.

- Mix and install non-shrink grout between reciprocating rotary equipment base frame including the filling of the equipment steel frame, if required, and concrete foundation in accordance with manufacturer specifications and project specifications.

13.4 Grouting of equipment shall proceed only when equipment setting has been accepted by OWNER.

14.0 ASPHALT PAVING

14.1 Mix and install asphalt paving over base courses installed by LSTK CONTRACTOR, in accordance with the specifications and drawings.

- Roads/ Driveways/ Parking areas/ Sidewalks/ Tank pads

14.2 The following work is included but not limited CONTRACTOR'S scope for installation of asphalt paving to.

- Installation of all materials necessary to make a complete installation.

- Installation of sub-grade, sub-base and base courses all properly compacted.

- Delivery and installation of all formwork, inclusive if any and all required supporting, bracing, pockets, cutouts, recesses, etc.

- Installation of expansion joints where required and/or construction joints

- Stripping of formwork and removal of all surplus material to LSTK CONTRACTOR'S yard or locations designated by OWNER.

- Mixing, delivery, installation, spreading and compaction of asphalt paving mixture in accordance with specifications.

- Any and all measures for proper asphalt paving installation and curing.

15.0 ROAD REPAIR AND MAINTENANCE

15.1 Supply and deliver necessary materials, equipments and labour to repair and maintain all plant roads, as necessary.

- Repair work shall be in accordance with the specifications.

- LSTK CONTRACTOR shall be responsible for repair of roads, all on the indication of OWNER due to the damage to the roads, caused by LSTK CONTRACTOR'S activities and construction operations, or due to faulty construction by LSTK CONTRACTOR. LSTK CONTRACTOR is not entitled for compensation for such repair work.
16.0 REPAIR OF DYKES, SLOPES AND DITCHES

16.1 Supply and deliver necessary materials, equipment and labour to effect repairs on dykes, slopes and ditches as necessary.

- Repair WORK shall be in accordance with the specifications.

- LSTK CONTRACTOR shall be responsible for repair of dykes, slopes and ditches all on the indication of OWNER’S representative, due to damage to the dykes, slopes and ditches caused by LSTK CONTRACTOR’S activities and construction operations, or due to faulty construction by LSTK CONTRACTOR.

- LSTK CONTRACTOR is not entitled for compensation for such repair work.

17.0 UNDERGROUND SEWERS AND PIPING SYSTEMS

17.1 Install the underground piping systems, in accordance with the specifications and drawings.

17.2 The following work is included but not limited to LSTK CONTRACTOR’S scope for installation of underground piping systems.

- Excavation including sheet piling, if required, backfill, compacting and the transportation of surplus material, neatly stockpiled at a location designated by LSTK CONTRACTOR and approved by OWNER.

- Installation of sand backfill if required

- Receiving unload, inspect and transport LSTK CONTRACTOR’S supplied materials and store and protect.

- Installation of piping materials necessary for a complete installation.

- The installation of above ground fire hydrants, fire monitors and standpipe as well as the underground firewater system.

- The fabrication and installation of supports and thrust blocks for the piping as required.

- Surface preparations and installation of coating and wrapping of the underground piping, if required as per Technical specification Mentioned in Annexure- 7 - 2C

- Installation of glass fiber reinforced epoxy piping in accordance with manufacturers instructions as well as the specifications.

- Hydrostatic pressure testing of the underground piping systems including test apparatus, test piping, test blinds, bolts and gaskets in accordance with the specifications.
17.3 **Hydro Testing of Sewers and Underground Lines**

- Tests all sewers and underground piping systems as per test instructions. Testing is to be witnessed and approved by OWNER. A test schedule by test system shall be prepared by LSTK CONTRACTOR. Testing and completion shall be in accordance with project system priorities.

- Piping systems shall be tested with suitable water.

- Develop test system procedures and follow priorities established by OWNER. LSTK CONTRACTOR shall prepare detailed schedules based on this data for submittal to OWNER for his approval.

- The water for testing purposes is to be provided by LSTK CONTRACTOR.

- Inexpensive temporary gaskets shall be used in place of permanent gaskets where test blinds are located for hydrostatic testing. On successful completion of a test, the permanent gasket shall be installed when the blinds are removed.

- After hydro testing, LSTK CONTRACTOR shall perform the following activities:
  - Flushing
  - Remove temporary blinds
  - Install permanent gaskets.
  - Flange connection bolts tightened.
  - Coat and wrap welds.
  - Holiday testing and coating repairs.
  - Backfill and compaction.

18.0 **CIVIL PART FOR UNDERGROUND ELECTRICAL GROUNDING SYSTEM**

18.1 Excavation of the routing for the direct buried cables, for the road crossing and for the branch conduit and sleeves in accordance with layout and detail drawings.

18.2 Transport of the excavated soil, neatly stockpiled to location chosen by LSTK CONTRACTOR and approved by OWNER.

18.3 Installation of all protection conduits and installation materials in accordance with the specification, and design and detail drawings.

18.4 Transport of excavated soil and backfill including compacting of the round up to finished plant level.

19.0 **CIVIL PART FOR UNDERGROUND CABLE TRENCHES (AND CABLE) CIVIL PART**
19.1 Excavation of the routing for the concrete cable trenches for the direct buried cables, for the crossings and for the branch conduit and pipe sleeves by machine or by hand as dictated by local conditions.

19.2 Transport the excavated soil, properly stockpiled to a location off chosen by LSTK CONTRACTOR and approved by OWNER.

19.3 Installation of the concrete cable trenches in accordance with the specification and the design and detail drawings.

19.4 For scope of installation of concrete cable trenches see item 11.

19.5 Installation of the road culverts, protection sleeves and cable ducts at road crossing in accordance with layout and detail drawings. For scope of installation see item 10

19.6 Transport of the excavated soil and backfill of the surrounding area of the concrete trenches up to finished plant level.

19.7 Transport of the excavated soil and backfill of road crossing up to road including the supply and installation of the repair of the paving and / or asphalt road covering.

19.8 Transport and backfill of the trenches with a layer of clean sand, free from stones equalized up to the bottom level of the first (bottom) cable layer.

19.9 Transport and backfill of the layer of clean sand between cable. Layers and above top cable layer.

19.10 Transport of excavated soil and backfill including compacting of the ground up to the layer of concrete tiles or trench covers.

19.11 Installation of the cable protection covers and/or trench covers and /or cable routing colored marking tape.

19.12 Transport of the excavated soil and backfill including compacting of the ground above the layer of concrete tiles up to finished plant level.

19.13 Installation of the cable route designated, trench markers.

20.0 STORAGE TANK PADS AND DYKES

20.1 Install tank pads as specified and as quantified on the specifications and drawings.

20.2 Install tank dykes and ramps as specified and as quantified on the specifications and drawings.
20.3 Install impervious clay layer inside the dyked tankage areas in accordance with specifications and drawings.

21.0 PERMANENT PLANT FENCING

21.1 Install permanent plant fencing, including personnel gates and truck gates as located, specified and quantified in the specifications and drawings.

22.0 SCAFFOLDING

22.1 Supply and erect all scaffolding for WORK.

22.2 Scaffolding shall be supplied, erected and maintained in strict accordance with local and governmental regulations as well as OWNER’S safety requirements. If there are conflicts, the more stringent shall prevail.

LSTK CONTRACTOR shall dismantle all its scaffolding at the completion of its WORK.

23.0 TESTING

23.1 All necessary tests in order to control the quality of the field works shall be done and all such test certificates should be kept in record, such as but not limited to

- Soil compaction tests.
- Concrete testing
- Asphalt testing
- Reinforcing bars testing

23.2 If any test fails LSTK CONTRACTOR shall replace those items, which do not meet the requirements.

All costs for replacements shall be borne by LSTK CONTRACTOR.

24.0 WELDING PROCEDURES SPECIFICATIONS AND WELDING PROCEDURE QUALIFICATION RECORDS

24.1 Provide within two months before starting the construction execution, its welding procedures (for A.G, U.G piping and any structural steel) for comment and approval. Approval of welding procedures by OWNER is required before the start of welding.

24.2 Prior to start of filed welding LSTK CONTRACTOR shall submit one (1) copy of all welders’ qualification paper and applicable welding procedures approved and stamped by regulating authorities to OWNER.

25.0 DRAWINGS AND DOCUMENTS

25.1 LSTK CONTRACTOR will carry out all construction activities directly from the AFC construction drawings and specifications.

25.2 LSTK CONTRACTOR shall submit reports of each test or inspection within three (3) days
after actual test or inspection. Failure to comply with the above rule may result in OWNER arranging for additional tests or inspections. Costs of which will be back charged to LSTK CONTRACTOR.

25.3 LSTK CONTRACTOR shall submit material certificates and quality records of the materials, as specified in previous sections and the applicable engineering specifications and standards.

25.4 LSTK CONTRACTOR shall also furnish a concrete installation record within two (2) weeks after completion of the WORK indicating, date of installation and quantity of concrete of each foundations, floor slab, elevated slab, frames, columns, etc.

This concrete installation record shall also show a reference with the concrete compression test certificates of the respective concrete pours and the concrete delivery slip numbers.

Failure to comply with the above time may result in the preparation of the documents by OWNER in which case all related costs will be back charged to LSTK CONTRACTOR.

26.0 MISCELLANEOUS

26.1 LSTK CONTRACTOR shall be fully responsible for the correct and accurate setting out of all elevations, positions, dimensions, alignments, profiles, etc. of all parts of the WORK and for the provision of all necessary instruments, appliances and labour in connection therewith. The checking of any such matter by OWNER shall not relieve LSTK CONTRACTOR of its responsibility for the correctness thereof.

26.2 If during the construction or maintenance of WORK, any error is discovered in WORK, LSTK CONTRACTOR shall at its own cost rectify such error to the satisfaction of OWNER. LSTK CONTRACTOR shall in such case take all necessary actions such as overtime, etc. in order not to endanger the agreed upon time schedule.

26.3 All dimensions shown on the plans and drawings are given in the SI system, unless otherwise stated.

26.4 All costs for setting out the earthwork and for assisting OWNER in checking the various points, lines, levels, profiles, etc. shall be deemed to be included in the price.

26.5 LSTK CONTRACTOR shall under no circumstances extend its operations outside the limits of the area appropriated for WORK. LSTK CONTRACTOR will ensure that its operations shall not interfere in any way with properties of others.

26.6 No excavation work shall be started before the exact positions of the WORK have been marked by means of stakes controlled and approved by OWNER.
26.7 OWNER shall notify LSTK CONTRACTOR of all known existing underground pipes, cables, drains, manholes, etc., in current use, together with the approximate locations and hazards involved and LSTK CONTRACTOR shall ensure that they will not be broken or damaged in any way by the execution of WORK. Hand labour shall be used for excavation within a horizontal distance of 1.5 meters from existing utilities.

26.8 Any damage as referred to above shall be reported by LSTK CONTRACTOR. LSTK CONTRACTOR shall repair the damage.

26.9 The discovery of any unregistered pipes, drains, cables, etc., shall be promptly reported to and dealt with as directed by OWNER. Excavation, as required to determine the exact location of existing underground pipes, drains, cables etc. shall be considered as a part of WORK.

26.10 LSTK CONTRACTOR shall take precautions i.e. mats, lining with timber, etc. not to cause damage to permanent plant roads curbing and sidewalks with its construction equipment.

26.11 LSTK CONTRACTOR shall provide and be responsible for the construction of all temporary dewatering. Drainage, sheet piling, timbering etc. to ensure the stability of slopes, trenches, embankments, etc. during excavation work and that all areas are adequately drained to the satisfaction of OWNER.

26.12 LSTK CONTRACTOR is responsible for all soil slides that may occur during the execution of the WORK and for any detrimental effect of the same. LSTK CONTRACTOR shall as directed by OWNER either correct or repair the damage to the satisfaction of OWNER at its own expense or pay for the cost of repair by others of all damage caused to the WORK or adjacent property. No additional payments shall be made to LSTK CONTRACTOR to compensate the financial consequences of soil slides.

26.13 Collapse, cave-in, or movement of excavations, trenches, or the like shall be the responsibility of LSTK CONTRACTOR. LSTK CONTRACTOR acknowledges this responsibility and instructions of the OWNER.

26.14 Trenches, excavations, and the like shall be maintained in strict accordance with the requirements of the applicable national and local regulations.

26.15 LSTK CONTRACTOR shall be held entirely responsible for any effect or damage, which the execution of any of the earthwork may have upon, or which may be caused to any portion of WORK or any of the surrounding property.

26.16 Excavation will proceed until all unsuitable material is removed.

26.17 LSTK CONTRACTOR is responsible for the excavation required to installing bottom of footings at elevations as shown on drawings. The removal of a poor soil below the intended bottom of excavation is included in the CONTRACT. Any unnecessary over excavation will be in LSTK CONTRACTOR'S account.
26.18 Backfill shall be to the elevation shown on the approved drawings or as directed in writing by OWNER.

26.19 Special care must be taken in compaction operations over underground pipelines.

26.20 LSTK CONTRACTOR shall furnish all field engineering, surveying, layout, and checking to properly install all foundations to meet all requirements of the drawings and specifications. On completion of each foundation LSTK CONTRACTOR shall mark all foundations with a clear center line, locating both North, South, East and West and a bench elevation mark. LSTK CONTRACTOR shall stencil or by other means, paint equipment and column designation and coordinates, to all foundations installed by LSTK CONTRACTOR. All markings shall be located above high point of paving. These markings shall be preserved for use by others.

26.21 LSTK CONTRACTOR shall design concrete mix specification and furnish by means of reports from OWNER'S laboratory, proof that the materials and mixes for concrete conform to the specifications and codes prior to pouring the first concrete on SITE. LSTK CONTRACTOR shall furnish all field labour to make concrete tests and fill cubes. Quality of concrete aggregates and mix design will be checked by OWNER'S laboratory regularly.

26.22 All aboveground concrete for supports for steel structures must be smooth finished, and exposed edges of concrete to have a chamfer.

The top of the foundations shall be poured so as to ensure true surfaces and designated slopes in all cases. LSTK CONTRACTOR is to avoid damage or movement of already installed reinforcement and/or other structures, formwork, etc., when pouring concrete.

26.23 All concrete pours for a given element must be monolithic, except where noted on the drawing or approved by OWNER.

25.24 If pouring cannot be finished within normal working hours, necessary actions shall be taken, sufficiently in advance for requesting permits for overtime. All pouring must be continued until the element is complete. OWNER shall be informed at least twenty-four (24) hours in advance.

26.25 Damaged formwork must be repaired in such a way as not to mark the concrete finish. All formwork must be braced adequately and be of a rigid construction. Gravel nests, surfaces crack, honeycombs, etc., and shall be repaired to the satisfaction of OWNER.

26.26 LSTK CONTRACTOR shall use immersion-vibrating equipment but it needs to be of a type approved by OWNER prior and also during use. Vibration of formwork and fresh concrete WORK is not allowed. OWNER will have the right to require replacement of inadequate during all phases of the WORK. A must condition shall be maintained after pouring as set forth in specifications. The WORK involved in this is to be included in the pricing.

26.27 OWNER reserve the rights to reject any WORK already poured which is not in accordance
with drawing and specifications and of adequate quality.

Serious inclusions appearing in concrete shall be reason for the rejection of WORK and LSTK CONTRACTOR requested to repair or replace at his own expense.

26.28 All costs involved in demolition, removal and replacement of rejected WORKS shall be the responsibility of LSTK CONTRACTOR all materials, equipment or auxiliaries not accepted by OWNER shall be removed immediately from the OWNER'S property.

26.29 Ready - mixed concrete shall be delivered without segregation. The concrete batch plant has to be approved by OWNER. Small quantities of concrete may be made at SITE after approval of OWNER.

26.30 The pouring of any reinforced concrete may only start after having obtained Approval of OWNER.

26.31 LSTK CONTRACTOR shall provide, during the period of this CONTRACT, temporary drainage ditches in WORK so that water will not be pended and so that all areas are adequately drained to the satisfaction of OWNER.

26.32 LSTK CONTRACTOR shall provide, during the period of this WORK, systems for the dewatering of all its WORK areas as required to properly execute the WORK. All dewatering methods shall be subject to the approval of OWNER.

26.33 All excavated boulders will be removed from SITE by LSTK CONTRACTOR.

26.34 Manholes are to be marked with M.H. Number.

26.35 Underground service lines have to be marked at their installation limits to aboveground piping, indicating line size, and service and line number.

26.36 Prefabricated concrete -items are to - be marked with date of fabrication, size, Length, identification code and installation north arrow.

27.0 BUILDINGS

27.1 LSTK CONTRACTOR shall do the construction of the buildings, including all activities and installations as specified, in drawing and specifications including the fabrication of all items that are not standard hardware components.

28.0 Quality of all civil and building materials shall be approved by OWNER before usage in the PLANT.
ANNEXURE- 7-2B

STRUCTURAL STEELWORK

1. Delivery of all materials and fabricated structural steel to SITE, including all required transport, storage, intermediate storage, etc., including loading and unloading of materials.

2. LSTK CONTRACTOR will carry out all construction from the AFC construction / erection drawings and specifications.

3. LSTK CONTRACTOR shall be held entirely responsible for any effect or damage, which the erection of the structural steel may have upon, or which may be caused to any portion of WORK or any of the surrounding property.

4. Erect Structural Steel-Structure Frames

This item covers all activities required to erect prefabricated structural steel framing for single and multilevel structures.

It includes, but is not limited to, the following:

- Provision of all tools, equipment and consumables used in the course of the work.
- Shimming of foundations and joints.
- Erecting.
- Cutting, drilling, welding and bolting to achieve fitment.
- Rectification required, if any.
- Final levelling, aligning and bolting (including torquing).
- Grouting of components and areas supplied unpainted or requiring finish coats, as per specifications.
- Touch up painting of damaged areas.
- Also included in this item are all clips plates, stiffeners, gussets, and connection material supplied loose for field installation.
5. **Fabricate and Erect Structural Steel-Structure**

This item covers all activities required to fabricate and erect structural steel framing for single and multilevel structures, from raw steel, if any, sections, plates, rounds, etc. It includes, but is not limited to the following:

- Provision of all tools, equipment and consumables used in the course of the work.
- Preparation of detailed fabrication drawings and getting them approved from Owner.
- Shimming of foundations and joints.
- Measuring, cutting, bending, bolting and / or welding.
- Erecting.
- Cutting, drilling, welding and bolting to achieve fitment.
- Final levelling, aligning, bolting and /or welding (including torquing).
- Grouting of support piers.
- Painting as per specifications.

6. **Fabricate and Erect Ladder and Safety Cages**

This item covers all activities required to fabricate, assemble and erect ladders and safety cages in steel structures, from raw steel (unpainted) sections, plates rounds, etc. It includes, but is not limited to, the following:

- Provision of all tools, equipment and consumables used in the course of the work.
- Preparation of detailed fabrication drawings and getting them approved from Owner.
- Measuring, cutting, bending, bolting and / or welding.
- Assembly and erecting including cutting, drilling, bolting, welding to achieve fitment.
- Cutting, drilling, welding and bolting to achieve fitment.
- Final Bolting and / or welding in position.
- Fabrication and installation of safety barrier rail and gate.
- Installation of raw bolts and forming of concrete pads, or connecting to a lower platform.
- Painting as per specifications.

7. **Fabricate and Erect Platform and Walkways**

This item covers all operations required to fabricate erect platforms and walkways on vessels, towers, structures, etc or on the ground from raw steel (unpainted) sections, plates, rounds, etc. It includes, but is not limited to, the following:

- Provision of all tools, equipment and consumables used in the course of the work.
- Preparation of detailed fabrication drawings and getting them approved from Owner.
- Measuring, cutting, bending, bolting and / or welding.
- Erecting including any, cutting, drilling, welding for fitment.
8. **Fabricate and Erect Welded Handrail**

This item covers all operations required to fabricate and erect double rail handrail and toe plate of all welded construction, from raw steel (unpainted) sections, plates rounds, etc.

It includes, but is not limited to, the following:

- Provision of all tools, equipment and consumables used in the course of the work.
- Preparation of detailed fabrication drawings and getting them approved from Owner.
- Fabrication including cutting, bending, welding, etc.
- Erecting of posts, top and middle rails toe plate including any cutting, trimming for pigment and welding.
- Grinding smooth of all cut edges and welds.
- Painting as per specifications.

9. **Fabricate and Erect Galvanized Tubular Handrails**

This item covers all operations required to fabricate and erect double rail tubular galvanized hand railing including all standards, fittings, bends, etc., from raw steel (unpainted) sections, plates, tubes, etc.

It includes, but is not limited to, the following:

- Provision of all tools, equipment and consumables used in the course of the work.
- Fabrication including cutting, trimming edge stripping to required size & shape.
- Erecting into position.
- Bolting and/or welding.
- Trimming to suit platform structure and providing openings for pipe or cable, etc.
- Making good edges, and touch up painting including cold galvanizing of cut or welded parts.
- Painting of unpainted steel sections.
10. **Fabricate and Install Floor Grating**

This item covers all activities required to fabricate and install galvanized floor grating from large sheets ready for cutting, trimming, etc., to platform shapes.

It includes, but is not limited to, the following:

- Provision of all tools, equipment and consumables used in the course of the work.
- Fabrication including cutting, trimming, edge stripping to required size & shape.
- Erecting into position.
- Bolting and/or welding.
- Trimming to suit platform structure and providing openings for pipe or cable, etc.
- Making good edges, and touch up painting including cold galvanizing of cut or welded parts.

11. **Fabricate and Install Chequer Plate Flooring**

This item covers all activities required to fabricate and erect chequer plate flooring, from sheets.

It includes, but is not limited to, the following:

- Provision of all tools, equipment and consumables used in the course of the work.
- Fabrication including cutting, trimming edge stripping to required size & shape.
- Erecting into position.
- Bolting and/or welding.
- Cutting to suit platform structure and providing opening for pipe or cable, etc.

12. **Erect Davits**

This item covers all activities required to erect fabricated davits on exchangers, vessels or in structures.

It includes, but is not limited to, the following:

- Delivery of davits and all other materials.
- Provision of all tools, equipment and consumables used in the course of the work.
- Erecting up painting of damaged areas.

13. **Roof and Wall Sheeting**

This item covers all activities required to erect bolting of roof and wall sheeting.

It includes, but is not limited to, the following:

- Provision of all tools, equipment and consumables used in the course of the work.
14. **Down pipes and Gutters**

This item covers all activities required to install metal downpipes and gutters.

It includes, but is not limited to, the following:

- Provision of all tools, equipment and consumables used in the course of the work.
- Erecting including fitting, trimming supporting and jointing.

15. **Roof or Ridge Ventilator**

This item covers all activities required for the erection of roof or ridge ventilators on a steel clouded building.

It includes, but is not limited to, the following:

- Provision of all tools, equipment and consumables used in the course of the work.
- Erecting on roof including any trimming or finial.

16. **Install Gantry Crane Rails**

This item covers all activities required to install rails.

It includes, but is not limited to, the following:

- Provision of all tools, equipment and consumables used in the course of the work.
- Erecting jointing levelling, aligning, and bolting or welding in passion.

17. **Install Gantry/Overhead Travelling Crane**

This item covers all activities required to erect and complete the installation of overhead cranes.

It includes, but is not limited to, the following:

- Provision of all tools, equipment and consumables used in the course of the work.
- Erecting into rails.
- Installing all controls, both mechanical and electrical.
- Testing and running of crane.

18. **Install Travelling Trolleys**

This item covers all activities required for the installation of beam mounted travelling trolley.
It includes, but is not limited to, the following:

- provision of all tools, equipment and consumables used in the course of the work.
- Erecting into position.
- All levelling and shimming of trolley beam as required.
- Marking of all beams and trolley with safe Working Load.
- All testing and running as required.

19. **Inspection and Testing**

- Inspection of steel structure shall be in accordance with the codes and standards.
- LSTK CONTRACTOR shall provide NDE services acceptable to OWNER. NDE inspection shall be carried out in accordance with standards, codes and specifications.
- LSTK CONTRACTOR shall be responsible for the repair of faulty welds and for all required extra radiography and inspection of the faulty welding work. In case of a faulty weld, 100% radiography on LSTK CONTRACTOR'S account can be done as per code.
ANNEXURE- 7 – 2C

PIPE PREFABRICATION AND ERECTION

1.0 PIPING

1.1 Magnitude of Piping

LSTK CONTRACTOR shall prefabricate, install and test all piping as shown on the plan drawings and isometrics.

2.0 PIPING FABRICATION AND ERECTION

2.1 Piping systems and pipe supports shall be designed, fabricated, inspected, and tested in accordance with rules, codes, specifications and drawings.

2.2 Miscellaneous piping materials for vents, drains, instrument connections, etc. on equipment shall be installed using P & ID’S and equipment drawings.

2.3 The fabrication and erection of piping includes field welds. It is LSTK CONTRACTOR’S responsibility to choose the number and location of field welds to ensure efficient transportation and handling during erection. Furthermore LSTK CONTRACTOR shall locate the field welds in such a way that final adjustment for fit-up purposes will be possible.

For alloy piping that has to be stress relieved after welding the number of filed welds shall be kept to a bare minimum. LSTK CONTRACTOR shall thoroughly evaluate the need for each field weld in alloy piping he deems necessary.

2.4 LSTK CONTRACTOR will furnish OWNER with a marked up set of isometrics identifying all spool pieces, and weld numbers. All piping spools shall be clearly identified, per isometric by means of stainless steel tags affixed with wire.

2.5 LSTK CONTRACTOR shall erect all prefabricated and straight run piping as required by the drawings and specifications.

The erection and installation of the piping shall include but not be limited to the following
- Control valves.
- Safety valves
- Rapture disks.
- Level instrument and gauges.
- External level displacers.
- Special fittings.
- Breaching of vents, drains, instrument connections, etc.
- Rota meters.
- Orifice flanges.
- Orifice plates.
- In-line instruments.
- Steam tracing.
- Steam traps.
- Extension stems. Valve operators.
- Bellows, expansion joints and similar specialty items.
- Thermowells (flanged, screwed and weld Ins.).
- Sample coolers.
- Instrument connections (up to and including the first block valve).
- Spring hangers and spring supports.
- Installation of miscellaneous piping and instrumentation supplied by equipment vendor.
- Temporary piping for drying, flushing and hydrostatic testing if necessary.
- Connection of piping to equipment.
- Connection of aboveground piping to underground piping.
- Pipe supports.

This shall include any necessary work to the piping to correct equipment misalignment.

2.6 Fastening of floor supports on concrete will be done with expansion type foundation bolts, if no anchor bolts are provided.

2.7 LSTK CONTRACTOR is responsible for the installation of steam tracing of piping, valves fittings and instruments where required, in accordance with the specifications and drawings. In general steam and condensate headers will be indicated on the piping plans. Lines to the traced will be indicated on P&ID'S and lines lists. Details of steam and condensate headers will be shown on separate drawings. Identification of steam tracers shall be by aluminum tag noting circuit number. Each end of system should be tagged.

A method of identification and tagging of the other various systems shall be established, subject to approval by OWNER and is for account of LSTK CONTRACTOR.

2.8 LSTK CONTRACTOR is responsible for the fabrication and erection of pipe supports, hangers, anchors and guides, as required by the drawings and specifications.

Spring pots and spring hangers, which shall be provided by LSTK CONTRACTOR as will be assembled, installed, adjusted and unlocked by LSTK CONTRACTOR after hydrostatic testing of the line. The required angle iron, will be decided in the field and supplied by LSTK CONTRACTOR.

2.9 LSTK CONTRACTOR shall install and remove all temporary strainers required for WORK defined herein. The removal of these items will be directed by OWNER. OWNER may decide to leave temporary strainers in during commissioning.
2.10 LSTK CONTRACTOR shall be responsible for the fabrication, installation and dismantling of temporary spool pieces and blinds required for control valves, safety valves and in-line instruments during testing and cleaning. Requirements for these shall be minimized. Requirements for these will be prescribed by OWNER.

In general, in-line instruments, safety valves and control valves may be installed for fit-up purposes if available to avoid the use of temporary spool pieces. They shall be removed for flushing and testing and reinstalled as directed by OWNER. In the case of safety valves these must be installed for fit-up, taken down for calibration by LSTK CONTRACTOR, and reinstalled before mechanical completion. All open flanges and valves shall be blinded or plugged off.

2.11 LSTK CONTRACTOR is responsible for the installation and testing of all piping and steam, electrical tracing and all materials including all items necessary to completely close the systems in strict accordance with the established test system procedures and priorities as directed by OWNER.

2.12 Wrapping & Coating:- Surface preparations and installation of Wrapping & Coating of the underground piping with Cold tape (Materials for line coating and wrapping shall be of Tape coating system (Polyethylene backed tape with butyl rubber based adhesive system), if required

2.12.1 Protective coating shall consist of a coating system employing Primer, Inner Wrap and Outer Wrap.

2.12.2 The coating system shall be mechanically applied by an approved type of wrapping machine utilizing constant tension brakes except at tie-in welds, repair patches and at other locations where mechanical application is not practicable.

2.12.3 Coating and wrapping materials shall be handled, transported, stored and applied strictly in accordance with the manufacturer's instruction.

2.12.4 Wrapping Coating material is Cold tape type from Polyken/Denso/Atla shall be used.

2.13 Flushing and Cleaning Of Piping Systems

i) Sections fabricated in LSTK CONTRACTOR'S workshop shall be fitted with plastic end caps to seal pipe ends, and jointing surfaces shall be suitably protected.

These caps shall not be removed until sections are in the course of erection after delivery at SITE and then shall be removed for refuse.

ii) During fabrication and erection the sections shall be inspected or internal cleanliness.

iii) The water which will be used for testing and flushing of the piping system shall be recollected per instruction given by OWNER.
v) Piping systems shall be flushed with suitable water as supplied by LSTK Contractor unless designated for nitrogen or air testing or otherwise specified by licensor. OWNER'S approval is required before start of flushing.

v) LSTK CONTRACTOR shall supply all equipment, pumps, gauges, etc. required for flushing and testing of the piping systems.

vi) For hydro testing and flushing the piping LSTK CONTRACTOR shall weld and caps and install drain plugs, remove end caps after successful hydro test.

3.0 HYDRO TESTING

3.1 Inspection and hydro testing of the piping systems shall be in accordance with the drawings and specifications and in strict witness by OWNER representatives.

3.2 Atmospheric pressure systems shall be:
- Visually inspected that all joints are properly made.
- Filled with water for a 24 hours leakage test under atmospheric conditions.

If any leakage occurs in the system during testing, repairs must be made without extra costs to OWNER.

3.3 LSTK CONTRACTOR shall test all piping systems as per the project test diagrams. Testing is to be witnessed and approved by OWNER and where applicable by the appointed (independent inspection authority) filed inspector. A test schedule by test system shall be prepared by LSTK CONTRACTOR and shall be submitted to OWNER for Approval.

3.4 Testing and completion shall be in accordance with project system priorities.

3.5 All equipment, pumps, gauges, pressure recorders temporary piping and fittings, test gaskets and bolting, required for testing of the piping systems and part of LSTK CONTRACTOR'S supply. Before testing LSTK CONTRACTOR shall calibrate its testing equipment.

3.6 LSTK CONTRACTOR shall supply and install blind flanges when required to enable testing of the lines.

3.7 Inexpensive temporary gaskets supplied by LSTK CONTRACTOR, shall be used instead of permanent gaskets where test blinds are located for hydrostatic testing. On successful completion of a test the permanent gasket shall be installed when the blinds are removed.

3.8 Piping systems shall be tested with suitable water. Extreme care shall be taken that suitable water is used for stainless steel systems. For stainless steel the water must be approved by OWNER and shall have a content of chlorides ≤ 50 mg/L

3.9 The water for testing purposes will be furnished by LSTK CONTRACTOR.
3.10 LSTK CONTRACTOR is to perform the testing in a sequence so as to allow sufficient time for insulation and/or painting to complete within the time frame of the project schedule.

3.11 A formal system of documentation will be developed by LSTK CONTRACTOR and approved by OWNER for use by LSTK CONTRACTOR to certify this testing phase of the piping erection. This system will also include a section for supplying OWNER'S "But list" comments.

3.12 Erected piping shall be hydrostatically tested in test systems, but not through equipment, control valves etc. except where piping is welded to equipment.

3.13 LSTK CONTRACTOR remains responsible for ensuring that no item of equipment, or instrument, is damaged by the test pressure or the test fluid. Suitability of test fluid to be Approved prior to testing by the OWNER.

3.14 It is emphasized that the installation of temporary strainers prior to testing shall be part of WORK. OWNER shall be contacted concerning installation of temporary strainers.

3.15 When lines are pressure tested, valves at the end of the lines must be covered with a test blank for safety reasons. A record, preferably on the test diagrams, shall be kept by LSTK CONTRACTOR indicating which sections have been completed.

Note: Testing against closed valves is not allowed (spades to be used)

3.16 All material damaged during tests shall be replaced on LSTK CONTRACTOR'S account. All joints broken after testing for installation of strainers, orifice flanges, safety valves, etc. must be remade tightly; labour is for LSTK CONTRACTOR'S account.

3.17 After testing the piping systems, they shall be completely flushed and drained. OWNER will approve when a line is considered flushed and drained by LSTK CONTRACTOR.

3.18 When each section or circuit has been pressure tested and passed, a certificate prepared by LSTK CONTRACTOR on LSTK CONTRACTOR'S furnished forms showing details must be signed by LSTK CONTRACTOR and OWNER, when the test has been completed and the system drained, test blanks must be removed by LSTK CONTRACTOR.

3.19 The following activities by LSTK CONTRACTOR are included for the reinstatement of piping after hydrotesting:

- LSTK CONTRACTOR installed temporary testing blinds to be pulled.
- Temporary spool pieces taken out.
- Gaskets renewed, temporary replaced with permanent.
- Flange connection bolts tightened.
- Post hydro punch list items corrected.

- Temporary strainers installed.

- Chemical cleaning performed.

- Supports and hangers checked if in final position.

- Rotating equipment cold alignment checked.

- Reinstallation of control and safety valves and in-line instruments which LSTK CONTRACTOR has removed for hydro-testing.

3.20 Nondestructive testing of welds and systems is to be performed in accordance with standards, codes and specifications prior to perform any hydro-test.

3.21 Wrapping Coating material for Under Ground piping is Cold tape type of Polyken or equivalent cold Tape to be used.

4.0 PIPING MATERIAL IDENTIFICATION AND PAINTING

4.1 All piping materials are supplied by LSTK CONTRACTOR and shall be properly stamped and color-coded to ensure that the correct materials are used as required by the drawings, specifications, codes and regulations.

4.2 All materials will be adequately marked as to its specifications. Should LSTK CONTRACTOR be required to cut same or otherwise render piece(s) to have no marking, LSTK CONTRACTOR'S transfer or replacement of proper identification marking to the pieces involved, must be done according to approved stamping method and to be counter stamped by LSTK CONTRACTOR. Paint alone is unacceptable.

4.3 The governing principle shall be that in the installed piping systems, all components can be identified and their origin and complete specifications can be determined. The method for identification and stamping or tagging of the various components of the system shall be worked out in coordination with OWNER and only be implemented after approval.

LSTK CONTRACTOR shall be held responsible for this requirement as a minimum, and any other requirements of local codes and regulations as to identification and documentation of materials.

4.4 Surface preparation and paint application of piping system by LSTK CONTRACTOR, shall be per paint specification.

4.5 LSTK CONTRACTOR shall assure that no welds are covered by prime coats prior to acceptance of hydrotest.
4.6 LSTK CONTRACTOR must ensure that all stamping such as code stamps, registration spool identification, charge numbers etc. shall be visible after paintwork.

5.0 WELDING
5.1 All welding shall be carried out according to codes and specifications.

5.2 Welder's qualification

5.2.1 All welders including those with valid qualifications will be required to submit a test conducted by OWNER prior to start of welding.

Welders that have a certificate which is still valid for the type of material and in accordance with ASME IX will not be tested by OWNER.

5.2.2 A current list of qualified welders must be maintained by LSTK CONTRACTOR and a copy furnished to OWNER each time a revision is made.

5.3 Welders' identification stamps shall be provided by LSTK CONTRACTOR. Each weld shall be clearly stamped with welders identification. All welding including tack welding shall be carried out by qualified welders. Unstamped welds shall be removed and replaced at LSTK CONTRACTOR'S expense.

5.4 Job SITE fabrication shall be carried out under cover where possible.

5.5 Weld spatter shall be knocked off around all welds leaving a smooth clean surface.

5.6 Where openings for branches are cut in run of pipe, all material, which may drop inside the pipe, shall be completely removed before the branch line is welded in place.

6.7 The interior welds of orifice flanges shall be ground smooth.

5.8 Electrodes, Rods, Wires and Fluxes

Electrodes shall be stored in the makers' airtight containers until required for use. Electrode heaters shall be used on Job SITE, for low hydrogen types of electrodes.

Electrodes and filler wires to be used at site in this job shall be procured from the approved vendors only. Electrodes and filler wires shall be D&H, Advani Orlikon or ESAB, Mailam and Bohler group make only

5.9 Open Air Welding

Where welding in the open air is unavoidable, WORK must be discontinued where the quality of the weld may be impaired by weather conditions. Including but not limited to airborne moisture, sand or high winds. After rain the metal surfaces shall be dried. For metal temperature below 5 °C joints to be preheated.

5.10 Welding Procedure Qualification
LSTK CONTRACTOR shall supply welding procedure specifications and qualification in accordance with the rules as set by OWNER.

5.11 Fees for inspection required for welding procedure and welders qualifications, supply of equipment required for the qualification test of welders and welding procedures are for account of LSTK CONTRACTOR.

5.12 **Inspection and Testing**

5.12.1 Inspection of welds shall be in accordance with the instructions of OWNER and/or the requirements of codes and standards.

5.12.2 LSTK CONTRACTOR shall be responsible for the repair of faulty welds and for all the required extra radiography and inspection of the faulty welding work. In case of a faulty weld, 100% radiography, on LSTK CONTRACTOR’S account, shall be done on the weld performed as per code.

OWNER shall have absolute discretion in the selection of the welds, which are to be radiographed.

5.12.3 LSTK CONTRACTOR shall provide NDE service, acceptable to OWNER.

NDT inspection shall be carried out in accordance with codes for all lines as indicated in the piping specification.

6.0 **STRESS RELIEVING**

6.1 LSTK CONTRACTOR shall provide stress-relieving service acceptable to OWNER. Spool pieces shall be stress relieved in an approved furnace equipped with thermostatic control and temperature recorder. Field welds to be stress relieved with electric resistance heaters. Temperature cycles to be monitored with portable temperature recorder.

6.2 Stress relieved welds shall be hardness tested by approved procedure and must meet criteria spelled out in specifications.

7.0 **TRANSPORTATION**

The following various categories of transportation of pipe, pipe fittings and prefabricated pipe spools will be performed by LSTK CONTRACTOR. All categories include loading and unloading materials. Categories will consist of but not limited to:

- From LSTK CONTRACTOR’S warehouse to LSTK CONTRACTOR’S pipe prefab shop.
- From LSTK CONTRACTOR’S pipe prefab shop to LSTK CONTRACTOR’S painting shop.
- From LSTK CONTRACTOR'S pipe prefab or painting shop to LSTK CONTRACTOR'S storage area or working area located on site or any other location on SITE.

- All transportation required performing nondestructive testing of prefabricated pipe spools.

8.0 **LIFTING, LIFTING EQUIPMENT AND GEAR**

8.1 Rigging and hoisting shall be executed as per construction specification and local requirements and safety rules, as manufacturer's instructions. If there are stringent one shall prevail.

8.2 **Testing And Certification**

All LSTK CONTRACTOR furnished cranes, lifting appliances and lifting gear must be properly tested, examined and/or inspected before being used on SITE, and at the intervals specified in the applicable regulations. Copies of the relevant certificates must always be available on SITE for inspection on request by OWNER or other authorities.

8.3 **Operation**

8.3.1 LSTK CONTRACTOR shall not permit a lifting appliance to be operated otherwise than by a person trained and competent to do so.

8.3.2 LSTK CONTRACTOR shall take express steps to ensure that all personnel employed by LSTK CONTRACTOR are competent and experienced for their assigned tasks.

9.0 **DRAWINGS AND DOCUMENTS**

LSTK CONTRACTOR shall fill in checklists as required by OWNER.

10.0 **MISCELLANEOUS**

10.1 LSTK CONTRACTOR shall furnish all field engineering surveying layout, and checking to properly install all above ground piping to meet all requirements of the drawings and specification. OWNER is authorized to reject any WORK already installed, which is not in accordance with drawing and specifications and of adequate quality.

10.2 All costs involved in demolition, removal and replacement of rejected works shall be the responsibility of LSTK CONTRACTOR. All materials equipment or auxiliaries not accepted by OWNER shall be removed immediately from SITE.

10.3 Underground service lines are marked at their installation limits to above ground piping, indicating line size, service and line number.

10.4 During storage, fabrication and erection, care must be taken to ensure that sand, scrap materials, welding rods, items of clothing and other foreign bodies are not allowed to enter piping.
10.5 All connections which are left open by LSTK CONTRACTOR shall be well protected, so that no sand, dirt or any foreign object come into the system.

10.6 In certain instances special bolting torques might be required on critical connections. LSTK CONTRACTOR will arrange WORK in accordance with these requirements.

10.7 Flanged piping connections to vessels or equipment shall be aligned and shall be properly fitted before bolting up. Piping may be heated to bring it into alignment only when approved by OWNER. Extreme care should be exercised to avoid damage. Heating, welding and flame cutting on equipment will not be permitted.

10.8 No cold springing or pre-stressing of piping will be allowed other than indicated on piping drawings, isometrics and manufacturer's instructions (e.g. for expansion joints).

10.9 Flange faces shall be clean and free from foreign matter before assembly. Damaged flange faces may be dressed with a medium cut file only if the damage does not require new facing. This shall be decided by OWNER.

10.10 During erection care shall be taken to remove all dirt, seals, sand and foreign matters from inside the pipe.

10.11 Since LSTK CONTRACTOR is responsible for both the prefabrication and the erection of all the piping, it is LSTK CONTRACTOR'S sole responsibility to ensure that all piping to be installed fits properly prior to lifting. LSTK CONTRACTOR is to check all equipment and underground piping to be piped to, for proper location and orientation. OWNER will not entertain any claims for extra work for:

i. Taking piping down for rework after it is lifted

ii. Re-lifting piping after it is reworked.

10.12 Final hookup of piping to equipment such as pumps and compressors shall be done together with the final alignment of this equipment and shall include checking of dimensions. Piping must fill these flanges without inducing any strain on equipment.

10.13 In all cases, all designated support and hangers should be in unlocked / cold position before final alignment. LSTK CONTRACTOR will be expected to expedite this critical phase of construction.

10.14 Certain small vessels will be considered to be piping items and shall be fabricated as such by LSTK CONTRACTOR.
ANNEXURE- 7 -2D

EQUIPMENT ERECTION

1.0 SURVEYING

1.1 Baseline and base elevation will be furnished to the LSTK CONTRACTOR. LSTK CONTRACTOR will furnish all surveying from this baseline and elevation.

1.2 OWNER shall have the authority at any time to determine in accordance with the drawings or written directives, the correctness or completeness of the lines in use by LSTK CONTRACTOR.

1.3 Any erroneous WORK shall be corrected to OWNER’S satisfaction at LSTK CONTRACTOR’S expense.

2.0 RIGGING STUDIES AND PLANS

2.1 LSTK CONTRACTOR shall supply rigging studies and plans as specified.

3.0 EQUIPMENT HANDLING

3.1 The handling of all equipment shall include, but not limited to the following activities by LSTK CONTRACTOR:

3.1.1 Submittal to OWNER of detailed rigging studies and plans for lifting, transporting and setting of equipment 4 weeks in advance of work for OWNER to review and approval. Complicated lifts shall be started in the morning and completed the same day.

The transportation plans are to include as a minimum:

Type of equipment to be used to transport each piece.

The planned route of the movement.

The estimated duration of the movement.

The obstructions to the route to be temporarily removed.

3.1.2 Receive, inspect, store, protect and perform preventative maintenance on all equipment in accordance with the specifications and drawings and/or equipment manufacturer’s instructions.

3.1.3 Prepare foundations, pipe sleeves, paving, concrete structures and steel structures for setting equipment.
3.1.4 Transport form warehouse or point of unloading and install equipment on foundations, paving or structures.

3.1.5 Plumb level and align equipment with coordinates in accordance with the specifications and drawings.

3.1.5.1 GENERAL

All of the equipment must be plumbed, leveled and aligned with the coordinates specified on the drawings both in plan and elevation and to the tolerances called out in the specifications, specific manufacturer’s instructions or recommended manufacture’s practices.

- LSTK CONTRACTOR will be required to verify field conditions and will be responsible for final alignment of mechanical items for this project. LSTK CONTRACTOR will check the anchor bolt locations against the equipment. Any deviation must be reported to OWNER in writing.

- LSTK CONTRACTOR will be required to supply and install shims required for all equipment erection. All cinch anchors required for equipment and supports will be supplied and erected by LSTK CONTRACTOR.

Prior to the placement of the equipment on a foundation, the surfaces of the foundation shall be cleaned of oil, grease, excess concrete and foreign matters by LSTK CONTRACTOR.

- Prior to setting the equipment on the foundations, the underside of the equipment base plate or supports will be cleaned free of oil, grease and other loose materials by LSTK CONTRACTOR.

- Anchor bolts shall be checked for damage to the thread and the threaded part shall be properly greased.

- Damaged anchor bolts must be replaced by LSTK CONTRACTOR and brought to the attention of OWNER.

- The openings between the anchor bolts and sleeves have to be cleaned of foreign materials to full depth of the opening by LSTK CONTRACTOR.

- All steel wear plates and guide keys shall be coated by CONTRACT with proper lubrication, prior to setting the equipment.

- Equipment shall be set true to line, at correct elevation and in proper orientation as shown and noted on the drawings.
- Maximum allowable setting tolerances shall be in accordance with manufacturer's requirements or with the specifications, whichever is more stringent.

- All equipment, unless otherwise specified, shall be leveled with shims at each anchor bolt (shim on both sides of each anchor bolt) and at intermediate points as required to prevent distortion of the equipment. Shims shall have square cut edges (not trimmed or sheared) and shall be of various thicknesses to minimize the number of shims required. Shims shall be supplied by LSTK CONTRACTOR.

- The equipment shall be set, leveled, aligned and inspected with precision tools (steel straight edge, graduated machinist levels, dial indicators, theodolites, water level instruments, turbine levels, etc.). Setting, leveling and alignment shall be according to manufacturer's recommended tolerances and specifications.

- There may be a number of items not installed by the manufacturer, i.e. seals, packing, lubricators, gauges, miscellaneous piping and tubing, thermometers, etc. that will come separately packed from the equipment itself that must be identified, stored, preferably inside in accordance with project criteria, and finally installed. LSTK CONTRACTOR is responsible for these activities.

- LSTK CONTRACTOR shall remove all temporary shipping supports or erection materials.

- LSTK CONTRACTOR shall do surface preparation for, and apply coating and wrapping on buried vessels before installation.

   Equipment supported on legs or on saddles shall be set to the tolerances specified in specifications of the required elevation measured on the flange of the largest diameter pipe-connecting nozzle.

- For equipment with sliding type supports, LSTK CONTRACTOR will remove dirt, grease or other foreign matter and will coat with graphite grease supplied by LSTK CONTRACTOR on the support.

- The anchor bolt nuts will be placed so as not to restrict the longitudinal movement of the sliding end.

- Vessels, drums, etc. shall be aligned, where applicable and leveled per shown or drawing.

- Shims shall be placed approximately evenly spaced under the support ring of vessels, drums, tanks.

- Towers with two or more pieces shall be assembled and welded at site by LSTK CONTRACTOR.

- LSTK CONTRACTOR is responsible to check and inspect at these equipments in the
- All costs are included in the lump sum price.

3.1.5.2 Rotating Equipment

- Rotating equipment will be installed in accordance with manufacture’s instructions.

Align drivers with all rotating equipment.

- LSTK CONTRACTOR shall install all ancillary equipment such as, but not limited to, drivers, guards, harness piping and all other interconnecting piping, casing drains, base plate drains and all necessary supports.

- The measurements for the positioning and leveling of mechanical equipment will be made on the suction flange.

- LSTK CONTRACTOR to install permanent packing, seals lubricating oils, greases and circulated oil systems.

- Services of manufacturer’s technical representative by LSTK CONTRACTOR shall be used to the fullest extent.

- Rotating equipment base plates will be supported for positioning and leveling on shims located as follows.

- For bases with four (4) anchor bolts, one set of shims will be placed adjacent to each anchor bolt.

- For bases with six (6) or more anchor bolts, two (2) sets of shims will be placed adjacent to each anchor bolt, one on each side of the anchor bolt.

- In addition shims shall also be placed directly under those parts of the base plate carrying the greatest weight and shall be placed closely enough to give uniform support.

- When the base plate is level in all directions as indicated by an accurate instrument on the machined pads, the anchor bolt nuts shall be brought down evenly, but not too firmly. The unit is now ready for grouting. After the grout has adequately set, pull the anchor bolt nuts down tight and recheck the base for levelness.

- Release for grouting of base plates must be approved by OWNER.

- After completion of the electric installation to the motor, the direction of rotation of the motor will be determined. Prior to checking the direction of rotation, the coupling between the motor and the equipment will be disconnected for the test run of motor by LSTK CONTRACTOR.
- Rough aligning of the centrifugal units and their respective drivers shall take place after the equipment has been put on the foundation.

- Coupling alignment

- Dial indicators shall be used and where possible optical alignment equipment.

Peripheral alignment shall be checked by using one dial reading peripheral differences between coupling halves as they are rotated together.

Face alignment shall be checked using two dials reading face-to-face differences between coupling halves.

- Tolerances shall be in accordance with manufacturer's instructions with and without pipe work connected.

- Manufacturer's representative shall check that the final alignment of equipment is satisfactory before any running takes place. For small equipment. Where it is agreed by OWNER that the services of a manufacturer's representative are not required, manufacturer's written instructions shall be followed.

- The final checks will be supervised by LSTK CONTRACTOR and the results recorded by LSTK CONTRACTOR and signed by OWNER and LSTK CONTRACTOR.

Final alignment shall be carried out in two stages.

- After piping is complete with all bolts removed from the flange connections.

- Final alignment with piping assemblies 100% complete and all flanges bolted up to ensure that no unforeseen vertical or horizontal pipe loading is imposed on the unit.

- The final aligning supervised by OWNER to make sure that the detailed instructions furnished by the equipment suppliers are carried out to the full satisfaction.

LSTK CONTRACTOR to supply qualified personnel in the final alignment activities.

- Prior to putting pumps, etc. into operation, loose equipment such as guards and gauges shall be installed by LSTK CONTRACTOR.

3.1.6 Mount the drivers to the rotating equipment in case of turbines and any large motors that are shipped separately.

3.1.6.1 In case electric motors have to be installed in the field, this shall be done after leveling of base plate, but prior to grouting.

Chrome / nickel shim martial, supplied by LSTK CONTRACTOR shall be used for alignment.
of drivers and pumps and shall be installed under the entire footing of the driver.

3.1.6.2 Equipment and drivers shall be doweled to bed plate if required by manufacturer's instructions.

3.1.7 Assembly whenever required for the items / package unit like Auxiliary Boilers, Waste Heat Boilers, Air - cooled exchangers, furnaces , compressors , Turbo generators etc. units as part of the scope of WORK of installation by LSTK CONTRACTOR.

3.1.7.1 Compressor seal oil and lube oil systems and control panels are included in LSTK CONTRACTOR'S installation of compressors.

3.1.7.2 When equipment is delivered in two or more sections for site welding the weld preparation must match accurately on mating sections before assembling.

3.1.7.3 LSTK CONTRACTOR shall assemble and erect items, whether skid mounted or supplied in individual components as specified in the requisition or indicated on drawings in order to make a completed unit.

3.1.7.4 Installation, assembly and alignment of the various components shall be done by LSTK CONTRACTOR.

3.1.7.5 Installation of air - cooled exchangers includes the erection of structural steel on the pipe rack, which will support the tube bundles must be done by LSTK CONTRACTOR.

3.1.7.6 Walkways, platforms, stairs, ladders shall be installed for the items / package unit like Auxiliary Boilers, Waste Heat Boilers, Air - cooled exchangers, furnaces, compressors, Turbo generators etc. by LSTK CONTRACTOR.

3.1.7.7 Drying out systems, refractory and linings is included in LSTK CONTRACTOR scope of work.

3.1.8 Install ladders, platforms, davits, pipe supports and pipe guides in accordance with drawings and specifications.

3.1.9 Open man ways. Inspect. clean and close man ways of all tanks, towers. vessels and other equipment as directed by specification or manufacturer.

3.1.10 Install all trays and vessel internals and support for same shipped loose. in accordance with drawings, specifications and manufacturer's recommended installation instruction.

3.1.11 Under the supervision of OWNER and respective manufacturer’s representative LSTK CONTRACTOR shall load the first loading of chemicals.

a) There will be certain items of equipment such as filters and package equipment that come with cartridges filled with desiccants, resins, etc. Their items will be installed by LSTK CONTRACTOR if they are shipped separately from the
b) Installations include the pick-up of these chemicals from the place of storage and transportation to point of installation.

3.1.12 Under the supervision of OWNER, LSTK CONTRACTOR install the first loading of catalysts. Installations include the pick-up of these catalysts from the place of storage and transportation to point of installation.

3.1.13 Touch-up of painting on new equipment after erection.

3.2 LSTK CONTRACTOR shall install grout under all equipment as required.

3.3 Grouting will be as per the specification per the equipment manufacturer's recommendation, whichever is more stringent.

3.4 The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of grouting:

3.4.1 Prepare top surface of base and/or plinth, pockets, sleeves etc., prior to placing grout.

3.4.2 Install grout mortar consisting of one part Portland cement and one part of clean sand and sufficient clean water for workability.

This grout mortar shall be used between steel base plate and concrete foundations.

3.4.3 Wherever non-shrinkage grout is specified on the drawings, the same shall be supplied by LSTK CONTRACTOR and installed in accordance with manufacturer's instructing.

3.5 Install non-shrink grout between reciprocating I rotary equipment base frame including the filling of the equipment steel frame if required, and concrete foundation in accordance with manufacturer specifications and project specifications. Type of non-shrink grout to be approved by OWNER. After grouting, shims used in leveling equipment will not be removed except where removal is specifically required by manufacturer's instructions.

3.6 Unless indicated otherwise on drawings vessels supported on skirts and support rings will be grouted using a stiff mix under the support ring so as to obtain full bearing. Grout will be placed within the area of the skirt the high point of ground at the vertical axis of the tower (or vessel), sloping downward to the support ring with four (4) weep holes under the support ring sufficiently large to ensure drainage.
4.0 MATERIAL HANDLING SYSTEM

4.1 ERECTION & COMMISSIONING

4.1.1 The complete material handling system including its all equipment shall erected at site and commissioned in accordance with the best engineering practice.

4.1.2 Packing, forwarding, transportation, unloading and storage at site, safety and protection of various components at site, insurance etc. shall be the responsibility of the LSTK Contractor / supplier.

4.1.3 All men, material and tools required shall be arranged by the LSTK Contractor at his own cost. The LSTK Contractor shall also arrange for the safe handling, storage, protection and security of his good at site.

4.1.4 The purchaser shall be responsible for supplying his part of material only as covered by the clause pertaining to the work to be excluded from LSTK Contractor’s scope of supply.

4.1.5 After erection at site, the belt conveyors and related equipment shall be tested for satisfactory operation for mechanical completion and full-load performance run. The LSTK Contractor shall carry out performance test as per mutually agreed procedure. The details of the procedure shall be submitted by the LSTK Contractor for purchaser’s approval.

4.2 MECHANICAL COMPLETION

4.2.1 Mechanical completion shall be considered as achieved when the system is mechanically complete along with the pre-commissioning activities and is ready for feeding. This shall include but not limited to the following:

1. The installation as per FINAL PROPOSAL is complete in all respects in accordance with the drawings, specifications including any approved changes thereto and in accordance with all applicable codes and laws.
2. The machinery, conveyors and all drives are aligned and run or cycled under no-load conditions.
3. The electrical system is installed and tested in accordance with applicable codes and specifications. All wiring is checked for correct hook-up. Motor rotation is checked and power system protective devices are set.
4. Painting is completed to the extent that the incomplete work does not prevent plant start-up and commissioning.
5. Successful completion of no-load test of all the equipment and the complete system.
6. Temporary construction facilities are removed to the extent necessary to permit the plant start-up and commissioning.
4.2.2 The OWNER shall inspect and certify that the LSTK Contractor executed the job in accordance with drawings and specifications.

4.2.3 When the complete belt conveyors and related equipment have been fully erected at site, LSTK CONTRACTOR shall request OWNER for his agreement to start the No-load Test Run. Owner shall, within 72 hours of receipt of such request, issue his agreement or advise LSTK Contractor in writing of any deficiencies noticed in the equipment.

4.2.4 Omissions / rectifications of minor items, if any, not affecting commissioning shall not withhold MECHANICAL COMPLETION as long as the LSTK Contractor agrees to supply / rectify the same within the specified period. The decision of the OWNER is final in this regard.

4.3 COMMISSIONING AND GUARANTEE TEST

4.3.1 After issue of Mechanical completion certificates by Owner, LSTK CONTRACTOR & OWNER shall mutually decide the date of commissioning of the equipment. From the date of commissioning, the equipment shall be gradually brought up to full load or any other load at the discretion of OWNER, and thereafter the equipment shall be run for a minimum period of 5 days. OWNER shall have the right to reduce this period where deemed necessary because of OWNER’s difficulties. During this period of 5 days of operation or the reduced period, the system shall run at an average of 90% of rated capacity. If the LSTK CONTRACTOR is not able to bring the load to 90% of the rated capacity as mentioned above within 2 (two) months, OWNER shall, without prejudice to any of his rights under the contract, has the right to take over the equipment and to proceed with modifications / rectifications / additions as he considers necessary at LSTK CONTRACTOR’s cost and risk to achieve this sustained load run.

5.0 PREPARE EQUIPMENT FOR OPERATION

5.1 Immediately prior to turnover, LSTK CONTRACTOR will make all the equipment ready for operation. This includes, but is not limited to such activities as:

5.1.1 Removal of preservatives and rust preventatives.

5.1.2 Installation of seals or removal of steel covers.

5.1.3 Removal of moisture absorbing materials.

5.1.4 Draining of oil reservoirs and the flushing and filling of the initial charge.

5.1.5 If required by OWNER for the final inspection the opening and closing of man ways of vessels and tanks.
5.1.6 Assisting equipment manufacturer's representatives by final checkout of equipment.

5.1.7 Remove all temporary supports, bracing, or other foreign objects that were installed in vessels rotating equipment or other equipment to prevent damage during shipping, storage, transport and erection.

5.1.8 Conduct all flushing, blowing and chemical cleaning required by the specifications.

5.1.9 Check and run in all rotating equipment, i.e. compressors, pumps.

6.0 Scaffolding Sufficient amount of scaffolding required for good performance of the WORK shall be supplied by LSTK CONTRACTOR.

7.0 DRAWINGS AND DOCUMENTS

7.1 LSTK CONTRACTOR will carry out all construction and any required procurement activities directly from the AFC construction drawings and specifications and forming part of the CONTRACT. No additional design work or development e.g. completion of drawings will be required from LSTK CONTRACTOR.

However, the plan type drawings called out to be supplied by LSTK CONTRACTOR in previous subsections of this section are included in LSTK CONTRACTOR'S scope of WORK.

7.2 All of LSTK CONTRACTOR'S drawings, calculations, documents, test reports, and test certificates are to be submitted to OWNER for approval in 6-fold. After receiving approval LSTK CONTRACTOR to submit for final approval all of the above and one (1) soft copy in CF format. LSTK CONTRACTOR drawings receiving "Approved as Noted" stamp may be worked on provided all notes are incorporated. It is understood that OWNER'S approval shall not receive in no way LSTK CONTRACTOR from any of his obligations and further more shall not relieve LSTK CONTRACTOR from his obligations to timely complete the WORK according to approved project schedule by OWNER.

7.3 LSTK CONTRACTOR'S drawings shall be clearly marked with titles, equipment numbers or other item identification.

7.4 Approval of drawings and calculations by OWNER in no way absolves LSTK CONTRACTOR from its responsibility for the accuracy or for the design, construction and timely performance of the WORK.

7.5 LSTK CONTRACTOR shall promptly submit reports of each and every test or inspection.

7.6 LSTK CONTRACTOR shall submit quality records of the materials, as specified in previous sections and the applicable engineering specifications.

7.7 LSTK CONTRACTOR shall furnish an equipment installation record indicating date of installation and tag number of each piece of equipment.

7.8 LSTK CONTRACTOR shall furnish an equipment maintenance record indicating date and type or maintenance of each piece of equipment during the LSTK CONTRACTOR period.
7.9 LSTK CONTRACTOR shall fill out checklists as required by OWNER.

8.0 LIFTING, LIFTING EQUIPMENT AND GEAR

8.1 Rigging and hoisting shall be executed in accordance with construction specification local and governmental requirements and safety manuals, as well as specific equipment manufacturer's instructions. If there are conflicts, the more stringent shall prevail.

8.2 LSTK CONTRACTOR shall only perform the lifts and movements in accordance with approved LSTK CONTRACTOR submitted rigging studies and plans.

8.3 Preferably, equipment will be lifted in accordance with manufacturer's instructions, if included, using lifting trunnions, lifting lugs if provided, or by slings attached to or around the equipment, with adequate protective measures to prevent damage to equipment. No temporary lifting lugs shall be used without the written approval of OWNER.

8.4 No nozzles or other appurtenances not intended for lifting shall be used for attachment of slings.

8.5 Equipment shall be handled with sufficient care to prevent damage. Slings shall have adequate protection to prevent marring the surface of equipment. Where necessary, sling spreaders shall be used to prevent crushing or other damage to the equipment.

8.6 Testing And Certification

All LSTK CONTRACTOR furnished cranes, lifting appliances and lifting gear must be properly tested, examined and/or inspected before being used on site and at the intervals specified in the applicable regulations. Copies of the relevant certificates must always be available on site for inspection on request by OWNER or proper authorities.

8.7 Operation

8.7.1 LSTK CONTRACTOR shall not permit a lifting appliance to be operated otherwise than by a person trained and competent to do so.

8.7.2 LSTK CONTRACTOR shall take express steps to ensure that all personnel employed by LSTK CONTRACTOR are competent and experienced for their assigned tasks.

9.0 WELDING

Welding of or on equipment shall only be permitted with the approval or OWNER.

10.0 EQUIPMENT PAINTING & INSULATION TOUCH

Rotating and special equipment to be erected by LSTK CONTRACTOR will be delivered to SITE finished painted. LSTK CONTRACTOR is responsible to apply remedial touch up painting for any damages to paint, or protective coatings on equipment handled by it in connection. With any aspect of this operations such as unloading, transport, handling and erection as per Annexure mention in ITB Section.
ANNEXURE- 7 - 2E

ELECTRICAL WORK

1.0 SCOPE : ELECTRICAL WORK COVERS

1.1 Installation and erection of the following equipment (items) consists of the preparation for installation, connection, testing and pre-commissioning etc. as per specifications and as per drawings.

1.2 Provision of all tools, equipment and consumables used in the course of the work.

1.3 The installation of the following systems (items) shall consist of the connection, testing and pre-commissioning etc., so that the systems are ready for use as per specifications and as per drawings.

1.4 Transport, store and protect supplied materials to the construction location.

2.0 ELECTRICAL ITEMS

2.1 Generators / Motors

2.2 Control panels

2.3 Transformer

Note : Installation of all accessories, tanks, levelling and fixing in place are also considered.

2.4 Switch Gears

Note : Bolting together sections where supplied separately and installation of panels, levelling and fixing in place are also considered.

2.5 Bus Ducting

Note : Jointing and securing the associated switch boards / transformers are also considered.

2.6 Battery charger, battery sets and UPS unit.

2.7 Cables in trench / conduit / tray / Rack.

Note : Following items are also necessary:

a) Measuring and cutting of cable and protection of cut ends.
b) Identification of cables

c) Fixing of cable to tray / rack

2.8 Cable Glands

2.9 Cable terminations

2.10 Earthing cable in trench / conduit / tape on tray / Rack

2.11 Earth cable tape terminations

2.12 Lightening protection

2.13 Lighting/ fittings / supports

2.14 Earth Rod PRT and cover

2.15 Cable tiles

2.16 Trench marker posts

2.17 Air craft warning

2.18 Underground electrical grounding system

Note: All below items are also considered:

a) Pulling of grounding cable in trenches, through culverts, protection sleeves and cable ducts as per grounding cable supplier installation instruction, project specifications and layout and detail drawings.

b) Coil up and clearly designate the final destination of the cable ends, especially if cables have to be continued their routing underground or overhead via cable tray or otherwise to their final destination at a later date.

c) Install, including the provision of the required tools, the required through branch and end connections.

d) Installation of all grounding electrodes including inspection pits as per specification and the layout and detail drawings.

e) Return of the cable drums to the storage area including a clear make up of cable length left on the reels of drums that are not empty.

f) Measure cable resistance for grounding continuity and grounding resistance of ground rods, record data and submit the rest result reports to OWNER prior to commissioning of the installation.
g) Check cables are in proper trenches and ground rods at their location.

h) Perform all test; witnessed by OWNER'S REPRESENTATIVES of the founding installation including the provision of all OWNER approved testing equipment and measuring devices.

2.19 Miscellaneous Electrical equipment

2.20 Earth resistance testing including earth resistance rods for grounding, continuity of grounding, installation resistance testing for electrical cables and HL-POT testing for electrical cables.

3.0 TESTING AND COMMISSIONING

Testing and commissioning consist of the complete testing prior to commissioning, including provision of required testing apparatus and testing documents as requested and as specified in the testing specifications.

- All test results shall be recorded on the test form and submitted to OWNER. Each test record shall include date of test, ambient temperature, climatic conditions, instruments used with serial numbers, names of test personnel and witnesses, identifications of equipment, ground electrode or circuit tested.

- Testing shall be scheduled at least 24 hours in advance and OWNER is to be notified by LSTK CONTRACTOR. LSTK CONTRACTOR will notify all necessary interested parties including manufacturer's representatives.

High potential tests shall not be repeated without authorization by OWNER.

4.0 DRAWINGS AND DOCUMENTS

4.1 LSTK CONTRACTOR will carry out all construction and any required erection activities directly from the AFC construction drawings and specifications.

4.2 LSTK CONTRACTOR shall promptly submit reports of each and every test or inspection.

4.3 For more details LSTK CONTRACTOR shall follow Electrical design philosophy elsewhere mentioned in ITB.
ANNEXURE- 7 – 2F

INSTRUMENTATION WORK

1.0 GENERAL

1.1 Instrumentation symbols and identification of functions shall be based on the current edition of ISA S5.1.

1.2 Specifications for instruments and items of control equipment are shown on data sheets to be issued as they become available.

1.3 All materials and connections for control valves, relief valves, level controllers and similar equipment shall comply with applicable requirements for valves and fittings as noted in the piping specification.

1.4 LSTK CONTRACTOR shall install all shim plates, fixing material such as but not limited to anchors, red heads, etc.

1.5 LSTK CONTRACTOR shall install all instrument equipment tag plates.

2.0 FIELD INSTRUMENT INSPECTION AND CALIBRATION AND INSTALLATION

2.1.1 This item covers all activities and supply of all materials to import calibration of instruments. It includes, but is not limited to, the following:

2.1.1 Provision of all tools, equipment and consumables used in the course of the work.

- Calibration of instruments and provision of all necessary test equipment gauges, materials and ancillary items. All necessary testing instruments to be used must be certified by Govt. recognized testing laboratories.

- Check orifice plates and control valves.

- Protection of instruments to maintain cleanliness at all times.

- Mark instrument to indicate status of calibration.

- Return instruments, after calibration and checking to lay-down areas and / or stores including all packaging.

- Pressure and leak test including the provision of all necessary test equipment gauges materials and ancillary items.

Note: The calibration of all instruments within the packages is also the responsibility of LSTK.
2.1.2 LSTK CONTRACTOR shall install all instruments as listed in the instrument index and further per the relevant installation specifications, documents and drawings.

2.1.3 Field instrument installation includes, but is not limited to:

Mounting of instruments and related equipment, supports protection boxes, manifolds, junction boxes, nameplates, etc.
Installation of measuring elements (probes, sensors, detectors, etc) including their auxiliaries as required (thermowells, supports, valves, etc.) unless done by others

Installation of on-line instruments (by piping)

The following is a typical list of on-line instruments:
- Safety blow down valves.
- Control valves (all types)
- Motor - operated valves.
- Safety shut - down valves (including solenoid valves).
- Safety / relief valves.
- Pressure / vacuum relief valves.
- Self - regulating valves.
- Level gauges.
- Level displacer chambers.
- Orifice assemblies.
- Orifice plates.
- Venturies.
- Turbine meters, annubars, magnetic flow meter.
- Positive displacement meters.
- Variable area meters (rotameters)
- Stilling Wells.
- Thermowells and etc.

- Installation of process connections, impulse lines and capillaries.

- Installation of purge and flushing supply tubing, filter blocks and rotameters.

- Installation of air supply lines.

- Supply and installation of instrument nameplates for field instruments.

2.2 Cable, Supports and Fixing Wire pins, Conduit

LSTK CONTRACTOR shall use for cable installation for indoor and outdoor use the materials such as tubing, cable trays, etc. as called in the specifications.

2.2.1 Cable tray, ladder rack and tubing systems shall be installed to ensure electrical continuity throughout the run and such that water cannot collect or remain in any part of the system.

2.2.2 Pulling of the cables into the trenches, through culverts, protection sleeves and cable ducts as per cable supplier installation instructions and layout drawings, cable lists, trench sections and reel schedules.

2.2.3 Installation of the cable separation tiles, if specified.

2.2.4 Coil up and clearly designate the final destination of the cable ends, especially if cables have to be continued their routing underground or overhead via cable tray or otherwise to their final destination at a later date.

2.2.5 Installation of the sealing shrouds to avoid water ingress after cable cutting.

2.2.6 Installation of the cable markers stamped with cable number by LSTK CONTRACTOR as per cable list.

2.2.7 Installation of cable splicing if required.

2.2.8 Return of the cable drums to the storage area including clear markup of the cable length left on the reels of cable drums that are not empty.

2.2.9 Check if cables are spaced as specified.

2.2.10 Measure cable resistance and cable insulation, record data and submit the test result reports prior to commissioning of installation.

2.2.11 Check whether all cables are installed in the proper trenches.
2.2.12 Perform all tests, witnessed by OWNER of the underground cable installation including the provision of the OWNER'S approved testing equipment and measuring devices.

2.2.13 Record of actual installed cable lengths and location of cable splices.

2.2.14 Where cables required to be installed through or across the edges of tray or other metal work the edge of the lips shall be smoothed, painted and lined with a protective sleeving to avoid cable damage.

2.2.15 Supporting steelwork shall be fabricated and installed by LSTK CONTRACTOR. The material shall be primed in accordance with the painting specification by LSTK CONTRACTOR.

2.2.16 Storage and handling of cable before and during installation shall be carried out with due regard to manufacturer's recommendations. Cable drums shall be rotated only in the direction indicated by drum markings, and open ends of cables are to be effectively sealed immediately after cutting to prevent the ingress of moisture.

2.2.17 At all times, the utmost care shall be exercised to avoid damaging the protective sheathing to cable or of causing excessive bending or twisting which may result in damage to core insulation, sheaths armor and so on.

2.2.18 The bending radius of a cable either during or after installation shall not be less than manufacturer's recommended minimum.

2.2.19 Cables shall be run in continuous unbroken lengths and joints shall not be permitted unless specifically called for in the cable drum-cutting schedule.

2.2.20 Cables installed above ground shall be routed to avoid high-risk areas, e.g. high fire risk areas, and those areas where accidental leakage or spillage may occur and cause damage to cables and supports.

2.2.21 During installation, the ends of cables shall temporarily be protected using compound, tape, heat shrink seals or similar approved methods to avoid damage or entry or moisture until they are permanently terminated.

2.2.22 Pre-cast concrete members should not be drilled for any reason. Fixing shall always be by means of clamping brackets in the most efficient way and in consolation with OWNER.

2.2.23 Under no circumstances shall welding be carried out to any process plant equipment, vessels, pipelines, or structures or to any protected surface unless specifically indicated on the drawings and documentation and then in strict accordance with a procedure subject to Approval of OWNER.

2.2.24 Fixings to the above shall normally be made where brackets and so on, have already been provided or when agreed by the use of purpose built clamps.
2.2.25 On trays horizontal cable runs shall be fastened every 1200 mm, vertical cable runs every 600 mm.

2.2.26 **Grouping**

The cables employed to convey electricity shall be grouped according to the signal kinds. The main group kinds are but not limited to the followings:

a) Intrinsically safe signals.
b) Signal cables not intrinsically safe.
c) Instruments power supply cables.
d) Coaxial cables or telephone cables used as serial data buses.

2.2.27 All cable trays, ladders, tubing and supports and fixing material for indoor and outdoor use shall be installed by LSTK CONTRACTOR.

2.2.28 All cables shall always be installed and connected in such a way that no forces can act on terminals. Further, all instrument and power supply cables inside and outside buildings shall be installed in accordance with both cable lists and drawings by LSTK CONTRACTOR.

Carbon steel coated cable stub ups shall be installed by LSTK CONTRACTOR for all cables from sand trenches to 500 mm above ground, in accordance with electrical connection detail drawings.

2.2.29 **Conduit system**

Single pair cables shall be used to connect field mounted instruments to local junction boxes. Single cables shall be armoured type laid in galvanized carbon steel / aluminium pipes with open ends or on closed cable trays. In order not to damage the cable, a plastic annular cap shall cover the pipe end.

Multipair cables shall be used to connect above said local junction boxes to the control room. Multipair cables shall be armoured type and shall run over head in closed cable trays / ladders supported on the pipe racks.

2.2.30 **Wire Pins**

All stranded cable conductors shall be fitted with crimped taper pins, amp (or equivalent) and all screens with lugs. Installation of all amp wire pins and screen lugs by LSTK CONTRACTOR.

Further, in general, all standby conductors shall be wired to terminals.

2.2.31 **Cable Marking**

All instrument cables, conductors and the instrument screen/earth wires shall be tagged on both sides in accordance with the instrument connection list for local and central control room signals by LSTK CONTRACTOR.
2.2.32 Cable Entry Sealing

- General

After installation of all cables and on direction of OWNER, LSTK CONTRACTOR shall seal off all cable entries and passages.

- Outside walls

All cable entries in outside walls and below grade level shall be watertight sealed. Method of sealing shall be supplied by LSTK CONTRACTOR.

- Separation walls

All cable entries in separation walls of buildings shall be sealed with a fire resistant sealing as described hereafter.

- Control Room Floors

All cable and cabinet entries in floors shall be sealed with polyurethane foam.

- Fire - resistant sealing

All fire resistant sealing shall be class H-30. Small openings in walls shall be sealed with CSD –F (or equal) in luminescent foam.

Large openings in walls and between computer floor and cable basement shall be sealed by inserting CSD-F (or equal) in luminescent plates under between and above the cables. The remaining openings shall be sealed with CSD-F (or equal) in luminescent foam.

2.3 Alarm Systems

2.3.1 LSTK CONTRACTOR shall install the fire alarm including sensors, cabling, local panels, mimic panels and host system. In accordance with:

- Project engineering specification and codes and standards.

- Cabling between panel and detectors, alarms, switches etc. as described above.

- Installation of all junction / terminal boxes, cable terminations and connections, supporting brackets for cabling as described above.

2.3.2 All work related to the fire and gas system, including overall test / loop check as per specifications and drawings, among which the installation, placing and connection of all cables of the fire and gas panel located in the control building and panel in the firehouse shall
be done by LSTK CONTRACTOR.

2.4  **Analyzers Installation**

LSTK CONTRACTOR shall install all analyzers and sampling conditioning systems in the analyzer house as well as in the field consisting of, but not limited to:

- Installation of all vents and drains from analyzers.
- Installation of calibration gas bottles as well as regulators and connecting tubing, as required.

3.0  **LOCAL PANELS**

LSTK CONTRACTOR shall install local panels, consisting of, but not limited to:

a) Mounting, aligning and fixing to the foundation or steelwork. Uncoil, install and terminate underground cable ends. Install and terminate all aboveground cable to / from panels.

b) Install and connect air supply and air signal piping and tubing to ‘from panels.

c) Install cabling and connect alarm horns.

d) Identification / tagging of all equipment, terminals, cables and tubing which is not installed by panel vendor. Tag plates to be installed by LSTK CONTRACTOR.

e) Installation of brackets / supports for cable, etc. and installation material as required to complete the installation.

4.0  **TERMINATION OF CONTROL CABLES FROM THE LV SWITCH ROOM**

The control cables running from the switch room shall be installed and connected in the marshaling cabinet by LSTK CONTRACTOR.

5.0  **CONTROL BUILDING INSTRUMENT INSTALLATION**

5.1  LSTK CONTRACTOR shall install all control building instrumentation in accordance with the relevant installation specifications and drawings.

6.0  **CABINETS AND CONSOLES**

6.1.1  LSTK CONTRACTOR shall install align and anchor all equipment cabinets and consoles in accordance with design drawings and seller's installation instructions.

6.1.2  The false floor shall be completely installed by LSTK CONTRACTOR.
All panels, cabinets, tables, boxes, computers etc. located on the instrument equipment layout shall be place and installed by LSTK CONTRACTOR.

6.1.3 Where cable passage is required according to installation drawings, LSTK CONTRACTOR to indicate locations of holes and passages.

6.1.4 FCS/ESD/PLC cabinets and data base unit:

These groups / cabinets shall be installed in place and bolted together by LSTK CONTRACTOR.

Internal wiring / cabling and / or connections between these groups of cabinets shall be done by LSTK CONTRACTOR in accordance with the instructions of the system vendor's representative.

6.1.5 FCS Consoles

The consoles shall be installed in place and bolted together by LSTK CONTRACTOR, including installation of special table with peripherals.

Internal wiring and cabling and/or connections between consoles shall be done by LSTK CONTRACTOR in accordance with the instructions of the system vendor's representative who will be present during these operations.

6.1.6 Communication racks with the same work description as specified elsewhere in Tender documents.

6.1.7 Main processor cabinets (data base units) with the same work description as as specified elsewhere in Tender documents.

6.1.8 Marshaling Cabinets

Cabinets shall be installed in place and bolted together by LSTK CONTRACTOR.

Cross wiring between these assembled sections shall be done by LSTK CONTRACTOR.

6.1.9 Fire Panel Cabinets.

6.2 Handling and installation. Termination and Connection of Cabling

Cables entering instrument room are installed under false floor. These cable shall be handled, cut to length, stripped and after installation of the cabinets be terminated and connected by LSTK CONTRACTOR.

LSTK CONTRACTOR shall leave slack in the cables and provide markings.
6.3 Installation of System Cables

LSTK CONTRACTOR shall install, plug in and support all system cables. Cable supporting rail in cabinets is installed by cabinet / console vendors, but in any case LSTK CONTRACTOR is responsible.

- System cable shall be installed by LSTK CONTRACTOR under false floor in auxiliary room. System cables are covered by instrument cable list.

6.4 Conduits Cable Tray / Trucking, Support Frames and Brackets

All cable trays, cable trucking, supports / brackets, etc. if required, shall be installed by LSTK CONTRACTOR. For cable tray installation see respective part.

6.5 Auxiliary Cable Installation and Termination.

LSTK CONTRACTOR shall install, terminate, support and connect all auxiliary cables.

Auxiliary cables are all cables covered by instrument cable list and instrument cable layout for control room.

LSTK CONTRACTOR shall open / remove and close parts of the false floor as required for cable installation.

6.6 Communication Cables

LSTK CONTRACTOR shall install and support communication cables. The connection of the cables in the consoles and cabinets shall be done by LSTK CONTRACTOR, under direct supervision of system vendor. LSTK CONTRACTOR shall open / remove and close parts of the false floor as required for cable installation. Communication cables are listed on instrument cable layout for control room and the system cable list.

6.7 Power Supply Cabling

LSTK CONTRACTOR shall install, terminate and connect all power supply cables between power distribution boards and cabinets, consoles, printers and other instrument equipment when listed on the power supply list.

6.8 Earthing System

LSTK CONTRACTOR shall install and connect the insulated earthing cabling / wiring from the earth buses to the cabinets, consoles and all other instrument equipment.

All cabinets and consoles shall be fitted with earthing bus bars and earthing connection bolts by the vendors and under supervision of LSTK CONTRACTOR.
LSTK CONTRACTOR shall install utility, shield and dedicated earth (clean earth) cabling and connections including tags at both ends.

LSTK CONTRACTOR shall check and test earthing system in accordance with relevant documents.

7.0 LIFTING

7.1 Major instrument equipment shall be rigged from points designated or suitable to accept rigging. When available, LSTK CONTRACTOR shall utilize lugs on equipment.

7.2 When establishing hoisting loads, riggings plans and crane capacities, LSTK CONTRACTOR shall adhere to the requirements and instructions as defined in the specifications and as instructed by OWNER.

8.0 TESTING AND PRECOMMISSIONING (FUNCTION TEST)

8.1 Testing and pre-commissioning consist of the complete testing and pre-commissioning prior to commissioning, including provision of required testing apparatus and testing documents, comprising, but not limited to:

8.1.1 Check for completion and conformance to specifications.

8.1.2 Check the accessibility of all instruments and components for field adjustments, routine maintenance and removal for overhaul, and relocate as necessary.

8.1.3 Perform pressure test on all air sub headers as required by the line specifications.

8.1.4 Clean all instrument air sub headers, transmission tubing and control tubing by blowing with dry, filtered air prior to connection of instrument components.

8.1.5 Leak test pneumatic transmission and control tubing, using an approved method acceptable to OWNER.

8.1.6 Perform hydrostatic or, where appropriate, pneumatic pressure tests on all instrument process piping, as required by the respective line specifications. Drain and below free of water, as necessary after test.

8.1.7 Check continuity and identification of transmission and control systems for each instrument to ensure proper hookup. Perform megger and continuity tests for instrument electrical wiring. Check correct source of power, polarity and earthing (take into account intrinsically safe technology of this procedure).

8.1.8 Check the bore of the orifice plates and flow direction during and after installation.
8.1.9 Check (on/off valve and) control valves for direction of flow and proper operation, e.g. travel, action with air failure, etc.

8.1.10 Calibrate all instruments (including the instruments in the fire and gas system) and synchronize transmitter and receiver readings for each instrument loop. Check the orifice plates and flow nozzles. Set air pressure regulators.

8.1.11 Install pressure and temperature gauges after line flushing.

8.2 Check fuses, perform voltage checks and energize all electrically powered instruments, alarm and shutdown system, etc. Maintain power supply.

8.3 Set pneumatic and electronic type switches and local control by simulation of input signals.

8.4 Check thermocouples and resistance thermometer circuits from element to measuring instrument by simulation.

8.5 Check and adjust calibration of all other field and panel mounted instruments.

8.6 Complete loop functional test of all instruments, including the instruments in all package units and in the fire and gas system. Functionally test complete control loops alarm and shutdown systems and partial process sequence, etc., to verify capability to measure, operate and stroke final control elements in the direction and manner required by the process application. All test results shall be recorded and submitted to OWNER. Each test record shall include date of test, ambient temperature, climatic conditions, instruments used with serial numbers, names of test personnel and witnesses, identification of equipment, ground electrode or circuit tested.

Testing shall be scheduled at least 24 hours in advance and OWNER is to be notified by LSTK CONTRACTOR. LSTK CONTRACTOR shall advise OWNER prior to testing, of make, type and accuracy of test equipment used for above-mentioned items. All required test certificates should be of a recent date not exceeding 6 months.

9.0 **PAINTING**

Surface preparation and application of all required paint layers shall be executed in accordance with paint specifications and related standards.

10.0 **WELDING**

LSTK CONTRACTOR shall perform welding in accordance with the normal accepted industrial standards.

11.0 **MECHANICAL COMPLETION**

LSTK CONTRACTOR shall advise OWNER in writing when erection is completed.

Mechanical completion date shall be the date when the activities have been accomplished by LSTK CONTRACTOR as dictated by the construction schedule, which shall be submitted by LSTK CONTRACTOR and approved by OWNER on due time.

12.0 **QUALITY ASSURANCE, QUALITY CONTROL, INSPECTION, CALIBRATION TEST AND MATERIAL CERTIFICATES**
12.1 LSTK CONTRACTOR shall perform quality control, inspect, calibrate required testing, pre-commissioning and supply certificates.

12.2 LSTK CONTRACTOR shall submit reports of each and every test or inspection within three (3) days after actual test or inspection is made.

12.3 Calibration and Testing.

12.3.1 Calibration and testing to be executed by LSTK CONTRACTOR in accordance with respective specifications.

Local instruments such as transmitters, converters, receivers and so on, will be preset by bench testing by LSTK CONTRACTOR in accordance with the specifications before installation on the process, so that no new settings will be necessary for loop acceptance tests.

12.3.2 LSTK CONTRACTOR shall inspect all materials upon receipt for damage and completeness. In case of damage incomplete material, LSTK CONTRACTOR shall modify and immediately inform OWNER.

12.3.3 LSTK CONTRACTOR shall carry out all tests included in this paragraph shall fill out the installation checklists and shall submit all required test certificates and documentation as required.

12.3.4 All tools and test gear necessary to carry out described tests shall be provided by LSTK CONTRACTOR.

12.3.5 Inspection and testing shall be phased with construction and installation in such a manner as to involve the minimum necessary concentration of effort and manpower and the minimum loss of time in reaching the pre-commissioning stage.

12.3.6 All inspection and testing shall be witnessed and approved by OWNER / authorized representative.

12.3.7 LSTK CONTRACTOR shall be responsible for the complete loop continuity check of the field and control room installation, including the parts of the package units, which have been connected by others.

12.3.8 OWNER reserves the rights whenever distinguished package Plant(s)/Unit(s) vendor's representative to be present at site LSTK CONTRACTOR shall be responsible to arrange this WORK.

12.3.9 LSTK CONTRACTOR shall be responsible for the loop continuity checks from the marshaling cabinets or direct connected cabinet cables in the control room (termination point of underground multi core cable). The loop continuity checks shall be performed on a complete loop, including all parts of the loop as indicated on the instrument loop diagrams (ILD’S).
12.3.10 The communication equipment between field and control room building and/or other buildings shall be the responsibility of LSTK CONTRACTOR.

12.3.11 Only complete loops shall be accepted, signed by OWNER after all calibration / function checks have been demonstrated successfully completed and recorded.

12.3.12 For all package units and systems supplied by LSTK CONTRACTOR, installed or partly installed and connected by LSTK CONTRACTOR.

LSTK CONTRACTOR shall perform a normal wiring and loop check of signals and supplies to and from these systems.

The following systems apply:

- Analyzer system
- Bentley Nevada system
- Flow metering system
- Fire, smoke and gas detection system
- Tank gauging
- FCS / ESD / PIC system, etc.

For more details LSTK CONTRACTOR shall follow Electrical design philosophy elsewhere mentioned in ITB.

13.0 Miscellaneous

LSTK CONTRACTOR shall remove all waste and debris from the SITE.
1.0 GENERAL

1.1 SCOPE
This standard covers the requirement for supply and application of materials for thermal insulation of equipment, piping and other items.

1.2 REFERENCE STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country. The main codes, standards and statutory regulations considered as minimum requirements are as follows:- (Latest revision of these shall be followed)

- IS 14164 Code of Practice for Industrial Application and finishing of thermal insulation material at temperature -80°C and up to 750°C.
- IS 737 Wrought aluminium and aluminium alloys, sheet, strip
- IS 1254 Specification for corrugated aluminum sheet
- IS 1322 Bitumen felts for waterproofing and damp proofing
- IS 3069 Glossary of terms, symbols and units relating to thermal insulation materials.
- IS 8183 Specifications for bonded mineral wool.
- IS 9743 Thermal insulation finishing cements
- IS 12436 Specification for Preformed Rigid Poly-urethane (PUF) and Poly-isocyanurate (PIR) Foams for Thermal Insulation
- IS 13205 Code of practice for the application of polyurethane insulation by the in-situ pouring method.
ASTM C450  Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging

ASTM C871  Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions


ASTM C1055  Guide for Heated System Surface Conditions that Produce Contact Burn Injuries

ASTM C1139  Specification for Fibrous Glass Thermal Insulation and Sound Absorbing Blanket and Board

ASTM D1622  Test Method for Apparent Density of Rigid Cellular Plastics

ASTM C680  Standard Practice for Heat Loss or Gain and Surface Temp.

1.3 Deviations:

Should unforeseen difficulties arise to comply with requirements of this standard.

Alternative material and application techniques superior to the requirements of this standard be submitted with complete details for approval of owner.

In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows:

1. Statutory regulations.
2. Job specifications.
3. Engineering design basis.

1.4 LIMITATIONS

Temperature Limits.

This standard deals with insulation applied externally on piping equipments etc. as per the table below:-

<table>
<thead>
<tr>
<th>Maximum Operating Temperature</th>
<th>Type of Insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>60°C to 750°C for C.S., A.S. &amp; S.S.</td>
<td>HOT</td>
</tr>
<tr>
<td>-180°C to 20°C</td>
<td>COLD</td>
</tr>
</tbody>
</table>

1.5 THICKNESS DESIGN BASIS

Thickness calculation method as per procedure given in ASTM C-680

1. **Hot Insulation**
   - Design Ambient Temperature : 35°C
Design Surface Temperature : 45°C
Permissible Heat Loss : 100 kcal./m2 hr.
Permissible Wind Velocity Outside : 1 m/sec
Permissible Wind Velocity Inside : 0.25 m/sec

2. Cold Insulation

Design Ambient Temperature : 35°C
Design Surface Temperature : 2 °C below ambient/ 0.5 Deg C above the Dew Point
Permissible Heat Gain : 10-12 kcal/m2 hr
Relative Humidity : 85%
Permissible Wind Velocity Outside : 1 m/sec.
Permissible Wind Velocity Inside : 0.25 m/sec.

1.6 GENERAL REQUIREMENTS

1.6.1 Information to be supplied

- Material of construction / dimension of equipments / pipes required to be insulated.
- Temperature
- Location of equipment (Indoor/Outdoor/Elevn.)
- Requirement of removable box type insulation if any
- Special requirements if any regarding type of insulation material and other properties.
- These information shall be supplied in form of insulation schedule.
- Design calculations, drawings and insulation material schedule.
- Material Test certificate’s.
- Insulation works execution schedule.
- Detailed procedure for all types of execution works.
- Bill of Quantities, Initial material take-off, final material take-off and material requisition.
- QA/QC plan.

1.6.2 STORAGE OF MATERIAL

Insulation material shall at no time be stacked directly on the ground; instead it will be stored at a level higher than ground level. It should not only be covered by tarpaulin but other effective protections against weather are also to be provided. The contractor shall provide a properly covered storage to the satisfaction of engineer-in-charge (Refer IS: 10556).

1.6.3 HYDROSTATIC TEST FOR PIPES

Before taking up insulation job on piping or vessels it shall be ensured that hydrostatic test of the concerned equipment / piping is completed. Where it is felt necessary to take up the insulation job before such testing are performed all welded and mechanical joints shall be left un-insulated for a length of at least 150mm on either side of the joint.

1.6.4 PROTECTION OF INCOMPLETE JOBS

Any part of insulation job which is not provided with final weather proofing will be adequately protected by means of tarpaulins and other aids. After the day’s work similar protection should be provided for the partially completed jobs to be continued the next day to avoid any absorption of rain / moisture during the night.
2.0 INSULATION SUPPORTS (CLEATS) TO BE PROVIDED BY EQUIPMENT SUPPLIER

Suitable supports (cleats) in the form of rings, lugs, studs or pins shall be provided on equipment by equipment supplier, however should any additional supports or anchorage be felt necessary for insulation works, the same shall be also considered in LTSK’s scope, including all allied work necessary for the same. These will be installed by the contractor free of any extra cost. Owner shall be informed about the same in advance, so also design/drawings shall be updated accordingly.

3.0 MATERIAL REQUIREMENTS

3.1 INSULATION MATERIALS

3.1.1 General

Whenever reference to any Standard is made it is presumed that the latest revision as on date should be considered unless otherwise specified.

3.1.2 Specification and other requirements

Specification and other requirements will be as per below mentioned table:-

### Hot Insulation:

<table>
<thead>
<tr>
<th>Operating Temperature</th>
<th>Insulation Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 400 deg.C</td>
<td>Rockwool Mattress of density 120 kg/m³ conforming to IS:8183.</td>
</tr>
<tr>
<td>401-450 deg.C</td>
<td>Rockwool Mattress of density 150 kg/m³ conforming to IS:8183.</td>
</tr>
<tr>
<td>451-500 deg.C</td>
<td>1st layer insulation shall be 25mm Ceramic Fibre Blanket of density 128 kg/m³ conforming to IS:15402 and balance layers with Rockwool Mattress of density 150 kg/m³ conforming to IS:8183.</td>
</tr>
<tr>
<td>501-550 deg.C</td>
<td>1st layer insulation shall be 50mm Ceramic Fibre Blanket of density 128 kg/m³ conforming to IS:15402 and balance layers with Rockwool Mattress of density 150 kg/m³ conforming to IS:8183.</td>
</tr>
<tr>
<td>551-600 deg.C</td>
<td>1st layer insulation shall be 75mm Ceramic Fibre Blanket of density 128 kg/m³ conforming to IS:15402 and balance layers with Rockwool Mattress of density 150 kg/m³ conforming to IS:8183.</td>
</tr>
</tbody>
</table>

Bands/Wires for securing insulation shall be of ASTM 8209 Alloy 3003 H16 or 18-737 designation 31000 (old NS3) condition H3 or 18/8 Stainless steel.

For securing cladding on insulation on piping, aluminium band 12mm (min) X 24 SWG thick shall be used. For securing cladding on insulation on equipment, aluminium band 20mm wide X 24 SWG shall be used.

Other insulating materials may be used provided they have the same or better properties and durability aspects.
Insulation thickness of insulating materials shall be based on design calculation of thermal conductivity, insulation class, etc. Same shall be submitted to the Owner with necessary design calculations, drawings, test certificates and durability parameters.

### For Valves, Turbines & Compressors Insulation

Prefabricated factory made Ceramic Fibre pad to be used made out of Ceramic Fibre Blanket of density 128 kg/m³ encased in high temperature resistant cloth. The minimum thickness of the pad shall be –

1. 0 Deg.C to 300 Deg.C = 25mm
2. 301 Deg.C to 400 Deg.C = 50mm
3. 401 Deg.C to 500 Deg.C = 75mm

Removable insulation for flanges and valves, like tailor made jackets or pre formed insulation boxes, shall be suitable for quick removal and reinstallation. All tailor made jackets shall fit the actual valve/flange/equipment and secure adequate overlap to incoming insulated pipes.

Technical data sheet of the Ceramic Fibre Pad is as below:

<table>
<thead>
<tr>
<th>A. Purpose/Application</th>
<th>This Engineering specification is for Fabric jacketed supercera ceramic Fibre insulated flexible reusable covers/pad for application on pipes: pipe fittings, valves, flanges etc vessels &amp; equipments, tubes etc in hot services.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Dimension (mm)</td>
<td>As per drawing/sketch provided by OEM.</td>
</tr>
<tr>
<td>02 Thickness (mm)</td>
<td>25-100</td>
</tr>
<tr>
<td>1. Specification of Protective jacketed material</td>
<td></td>
</tr>
<tr>
<td>i Vest Cover</td>
<td>Liner Fibre Glass Fabric</td>
</tr>
<tr>
<td>ii External Top Cover Fabric (for cold face)</td>
<td>Polymer Coated Fibre Glass fabric Temp. resistance 300 Deg. C, oil &amp; water resistant</td>
</tr>
<tr>
<td>iii External Bottom Cover fabric (for hot face)</td>
<td>High silica cloth for Temp Resistance up to 900 Deg C</td>
</tr>
<tr>
<td>2. Specification of insulation Material</td>
<td>Ceramic Fibre Blanket (As per IS 15402)</td>
</tr>
<tr>
<td>i Classification Temperature</td>
<td>1260 degree Celsius</td>
</tr>
<tr>
<td>ii Thickness</td>
<td>25 – 100mm</td>
</tr>
<tr>
<td>iii Bulk Density</td>
<td>128kg/m³</td>
</tr>
<tr>
<td>iv Shot content on 70 mesh (%)</td>
<td>&lt;30</td>
</tr>
<tr>
<td>v Tensile strength (KPa)</td>
<td>&gt;40</td>
</tr>
<tr>
<td>vi Mean Fibre Dia (Micron)</td>
<td>2-4</td>
</tr>
<tr>
<td>vii Linear Shrinkage (%) At 1200 Deg. C for 24 Hrs</td>
<td>3.5</td>
</tr>
<tr>
<td>viii Thermal Conductivity (W/mK) Max.</td>
<td>1000°C</td>
</tr>
<tr>
<td></td>
<td>0.046</td>
</tr>
<tr>
<td>ix Chemical composition</td>
<td>SiO₂%</td>
</tr>
<tr>
<td></td>
<td>Al₂O₃%</td>
</tr>
<tr>
<td></td>
<td>ZrO₂%</td>
</tr>
<tr>
<td></td>
<td>FeO₃%</td>
</tr>
<tr>
<td>3 Hardware &amp; Non Metal fastening</td>
<td></td>
</tr>
<tr>
<td>i) Buckle/Draw Stings</td>
<td>Stainless steel (min SS 316), High Temp Braided Chord of</td>
</tr>
</tbody>
</table>
Rockwool Insulation shall be of water Repellent Grade and tested as per BS: 2972 for Water Absorption. Maximum water absorption is 0.5 kg/m² in 48 hours duration.

Precautions must be implemented in the design and fabrication of the insulation jackets to avoid the insulation material from sagging causing reduction of the insulation properties of the jackets.

**Cold Insulation:**

Insulation material and specifications for cold insulation for operating temperatures up to (-) 180°C and dual temperature (cold/hot) service where, upper temperature limit is 125°C shall be as given below for all sizes of piping/equipment:

- **Polyurethane Foam**

  Preformed pipe section’s and radial lags (for higher diameter pipe) of polyurethane foam of self-extinguishing type shall be in accordance with ASTM C591 TYPE-II Grade 2. The physical requirement of bulk density, chloride content, thermal conductivity and PH value of the material shall be as follows:

  - Temp. Limit Bulk density: Upto (-)180°C & 120°C (max) 35.0 to 39.9 kg/m³
  - Chloride content: 20 ppm (max)
  - Thermal conductivity: 0.221 mw/cm°C at mean temp. 10 deg C
  - PH Value: Neutral.
  - Closed cell content: 95% (min)

  High density polyurethane foam block of bulk density more than 300 Kg/m³ shall be used for supports.

- **Polyurethane Foam Cast-in-Situ**

  Cast-in-Situ Polyurethane Foam of density 42±2 kg/m³ conforming to IS: 13205 shall be used. High density polyurethane foam block of bulk density more than 300 Kg/m³ shall be used for supports.

  - Temp. Limit: Up to (-) 45°C and 120°C (max.)
- **Polyisocynaurate**

  Temp. Limit :  Up to (-) 180°C and 125°C (max.)

  Other insulating materials may be used provided they have the same or better properties and durability aspects.

  Insulation material specification/ thickness/application mentioned in this document are the minimum requirements. Insulation specification/ thickness/ application shall be based on design calculation of thermal conductivity, insulation class, relevant IS/ ASTM codes etc. Same shall be submitted to the Owner with necessary design calculations, drawings, test certificates and durability parameters. LSTK shall submit detailed material specifications, durability parameters assured, test certificates and application procedure to OWNER/ PMC approval.

### 3.2 AUXILIARY MATERIALS FOR CLADDING

a) **Aluminium Cladding**

   - **Horizontal Vessels**
     
     Aluminium sheet as per IS-737 (designation 31000, condition H3 for flat sheet & 31500/51300, H4 for corrugated sheets)) shall be used for cladding. Insulation on overall piping, vessel and equipment, cladding will be coated on the side in contact with insulation with 3 mil thick polysurlyn film.

     Specifications for aluminium Cladding material shall be as follows:

     | Material | Reference Code / Standard | Thickness | Application |
     |----------|---------------------------|-----------|-------------|
     | Aluminium sheet with applied moisture barrier of 3 mil thick Polysurlyn coating | IS : 737 / ASTM C-653 | 22 SWG (0.71mm) | For all piping, tanks, vessels, heat exchanger, flanges, valves, equipments etc. upto 24” outside dia |
     | | | 20 SWG (0.91mm) | For piping, tanks, vessels, heat exchanger, flanges, valves etc. above 24” outside dia |

     Removable cover for flanges, valves etc. shall be made out of minimum 18 SWG thickness Aluminium Sheets.

   - **Vertical Vessels**
     
     Cladding material for vessels with insulation O.D. 900 mm and less shall be same as for pipes. For vessels above 900 mm insulation O.D. 22 SWG corrugated aluminium sheet as per IS-1254 or ribbed aluminium sheet 32 mm x 5 mm deep corrugations may be used.

     Aluminium Foil to protect stainless surfaces in Temperature below 0 deg c shall be 0.1 mm (42 SWG) thick per ASTM 8209 alloy 3003 H16 or IS-737 designation 31000 (0IdNS3) condition H3. For securing aluminium foil on stainless steel surface 24 SWG thick x 20mm wide aluminium bands shall be used.

b) **Screws**
Screws used with aluminium sheeting shall be of self tapping type, A No.8x12mm long cadmium plated / SS of high quality at intervals of 150mm.

c) **S-Clips.**
   Aluminium, 20x1.5mm or 25mm wide stainless steel banding bent to form a shape of “S” provide a minimum lap of 50mm.

d) **Bands for securing cladding.**
   Aluminium of dimensions 12mm width x 0.56 mm thick (24 SWG) for pipes. Stainless Steel bands Type 304, 0.4mm thick x 13mm wide for large dia pipes (above 24”) and cylindrical equipment up to outside dia 900mm, 0.5mm thick x 19mm wide for cylindrical equipment above 900mm outside dia meter.

e) **Quick release clips for removable covers.**
   Suitable quick release clips will be made as shown in fig. 7 from 20Cm width x 20 SWG aluminium sheet and some fig.7 from 20mm width x 20 SWG aluminium sheet and some suitable rectangular ring.

f) **Sealant for cladding joints with Foster 95-44 / TIKI F9544.**

g) The vapour barrier mastic shall be Foster 60-38/39 / TIKI M6038/39

h) Adhesive for cold insulation shall be Foster 81-33 / TIKI P8133

i) Vapour Stops at pipe support location shall be Foster 90-66 / TIKI F9066

j) **Rivets:** Aluminium ‘POP’ blind eye type / Stainless Steel 9.5mm long x 5mm dia meter.

k) Filler material shall be PUF dust or mineral wool mixed with specified adhesive shall be placed lightly so as to fill irregular voids and sealant shall be Foster Foam Seal Sealer 30-45. Glass cloth to be used for vapour barrier reinforcement shall be open weave 10 mesh having glass fibre thickness of 5 mils.

Galvanised steel sheets/ Annealed galvanised steel sheets/ Galvanised colour coated sheet are strictly **PROHIBITED** for use in cladding works. Other cladding materials (except G.I.) may be used provided they have the same or better properties and durability aspects, after prior approval from Owner/PMC.

Cladding material / auxiliary material specification/ thickness/ application mentioned in this document are the minimum requirements. Cladding material/ auxiliary material specification/ thickness/ application shall be based on design calculation of thermal conductivity, insulation class, corrosion aspects, durability, relevant IS/ ASTM codes, etc. Same shall be submitted to the Owner with necessary design calculations, drawings, test certificates and durability parameters.

LSTK shall submit material specifications, durability parameters assured, test certificates and application procedure to OWNER/PMC approval.

**4.0 Inspection.**

**4.1 General**

All insulation material shall be subject to inspection by owner before application. In case of doubt, Owner’s representative will have the liberty to get the material tested by the contractor at any approved test laboratory. Any material not meeting specified requirement will be rejected and the rejected material shall have to be replaced by the contractor with material of specified type and quality. Insulation found to be improperly installed shall be removed and reinstalled properly by the contractor.
Contractor shall maintain detailed log of various insulation works and same shall be updated on daily basis. QA/QC checks of work done and materials shall be also registered in the daily logs. Owner will have the liberty to check the logs.

4.2 Inspection

Inspection of materials and/or installation by owner shall not relieve the contractor of his responsibility to ensure that finished insulation conform to specified requirements and is free from defects, contractor shall correct any defects due to poor workmanship. Contractor shall maintain test certificates and other relevant data from manufacturer.

4.3 Test for thickness

Test for thickness shall be carried out after application. Thickness at any point shall not be less than 2mm than the indicated designed thickness and excess thickness up to 115% of the designed thickness is permissible.

4.4 Testing for bulk density

Testing of bulk density of the insulating materials shall be carried out before the application of insulation. This should be within ±15% of the specified value. Test location shall be selected by owner and its repair shall be done by contractor.

5.0 APPLICATION

5.1 General

Insulation thickness shall be as per design calculations as specified in the drawings/insulation schedule/specification/isometric drawings prepared for equipments/piping.

Contractor shall submit detailed calculations and procedure for different insulation works based on relevant IS/ASTM codes.

5.2 No. of Layers

When insulation thickness exceeds 75 mm, the insulation shall be applied in multi-layers with all joints staggered. Each layer will be separately secured with metallic bands/wires.

No. of layers shall be as follows:

<table>
<thead>
<tr>
<th>Insulation Thickness</th>
<th>No. of Layers (Min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 75mm</td>
<td>1 Layer</td>
</tr>
<tr>
<td>76 to 150 mm</td>
<td>2 Layers</td>
</tr>
<tr>
<td>151 and above</td>
<td>3 Layers or more</td>
</tr>
</tbody>
</table>

5.3 GENERAL REQUIREMENTS

5.3.1 Surface preparation
- Surface to be insulated shall be cleaned of all dirt. Oil loose scale etc. by wire brushing. Insulation works shall commence only after necessary clearance from QA/QC for painting works as per painting specification. All insulation shall be applied at ambient temperature and both the metal surface and insulation material shall be dry prior to application of insulation.

- The surface for cold insulation shall be then coated with a bitumen emulsion or a mastic coating.

- If the vessel is made of stainless steel, it shall be wire-brushed with stainless steel wire brush.

5.3.2 Expansion / contraction joint

Depending on the type of insulation used the operating temperatures and nature of the material it may be necessary to provide expansion/contraction joints on vessels or pipes to prevent the insulation from rupturing/buckling when the surface expands/contracts. Joints are to be designed as per relevant IS / ASTM codes.

5.3.3 Filling of Voids

All voids, irregularities and joints shall be packed with loose insulation material/insulation cement trowelled smooth whichever is applicable.

6.0 MEASUREMENT OF INSULATION WORK.

6.1 Measurement of insulation works shall be as per IS: 14164.

7.0 GUARANTEE

- There shall be a surface temperature recording as mentioned in the Design Parameter to be performed with the help of Thermography Camera, post the line/ equipment is charged in operating conditions. The same shall be in LSTK’s scope and LSTK shall give a detailed report of the same.

- The guarantee test shall be carried out when plant is fully operative.

- The surface temperature, reading shall be taken at six points per pipe line and at each point it shall be taken on all four sides in top, bottom, left side and right side.

- The above reading shall be taken at 2 hours intervals and shall be taken for 18 hours starting from 11 a.m. in the morning.

- Simultaneously ambient temperature shall be taken as per IS: 14164

- A graph shall be plotted between ambient and surface temperature reading

- From this graph the surface temperature against ambient temperature shall be found out

- The ambient and surface temperature shall be measured by the instrument provided by the contractor. The instrument shall be calibrated to the satisfaction of owner/consultant.

- The contractor is required to guarantee the surface temperature of 60°C (max.) for equipments and piping in case of Hot Insulation. For cold insulation of equipments and
piping, the difference between skin temperature and ambient temperature shall not exceed 2 °C.

- Ambient temperature and surface temperature shall be measured by duly calibrated instruments provided by CONTRACTOR.

- The CONTRACTOR shall undertake immediate replacement of insulation material damaged in transit, storage or application, at no additional cost to Owner.

- LSTK shall produce required number of copies of test certificates as per relevant IS/ASTM Standard. LSTK shall certify/ensure that Test to be done are from NABL approved laboratory, approved by Owner.

- All materials are new and unused and are as per specifications called for in this standard.

- The operating thermal conductivity shall be as specified

- The workmanship shall be in accordance with good practice.

- **Other terms & conditions of the guarantee clause shall be as per NIT / purchase order / Commercial documents of ITB.**
1.0 GENERAL

1.1 Scope
This specification covers the technical requirements for shop and site application of paint and protective coatings and includes; the surface preparation, priming, application, testing and quality assurance for protective coatings of mechanical equipment, structural steelwork, plate work, tankage, guards, pipe work, handrails and associated metal surfaces, which will be exposed to atmospheric for the Project.

1.2 Definitions
- C.S - Carbon steel and low chrome (1-1/4 Cr through 9 Cr) alloys
- S.S - Stainless steel, such as 304,316, 321, 347,
- Non-ferrous - copper, aluminium and their alloys.
- High Alloy - Monel, Inconel, Incoloy, Alloy 20, Hastelloy, etc.
- DFT - Dry Film thickness, the thickness of the dried or curved paint or coating film.

1.3 Safety Regulations
Protective coatings and their application shall comply with all national, state, and local codes and regulations on surface preparation, coating application, storage, handling, safety, and environmental recommendations.

Sand or other materials producing silica dust shall NOT be used for any open-air blasting operations.

1.4 Material Safety Data Sheets
The latest issue of the coating manufacturer’s product datasheet, application instructions, and Material safety data Sheets shall be available prior to starting the work and shall be complied with during all preparation and painting / coating operations.

1.5 Materials
All paints and paint materials shall be obtained from the company’s approved manufacturer’s list. All materials shall be supplied in the manufacturer’s containers, durably and legibly marked as follows.

- Specification number
- Colour reference number
- Method of application
- Batch number
- Date of Manufacture
- Shelf life expiry date
- Manufacturer’s name or recognised trade mark.
2.0 CODE AND STANDARDS:

Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, the following codes & standards shall be followed. Wherever reference to any code is made, it shall correspond to the latest edition of the code.

2.1 Indian Standards:

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS-5: 1994</td>
<td>Colors for ready mixed paints and enamels.</td>
</tr>
<tr>
<td>IS-2379: 1990</td>
<td>Color codes for identification of pipe lines.</td>
</tr>
<tr>
<td>IS-2629: 1985</td>
<td>Recommended practice for hot-dip galvanizing on iron and steel.</td>
</tr>
<tr>
<td>IS:110</td>
<td>Specification for Ready Mixed Paint, Brushing, Grey Filler, for Enamels, for Over Primers</td>
</tr>
<tr>
<td>IS:101</td>
<td>Methods of test for ready mixed paints &amp; enamels.</td>
</tr>
</tbody>
</table>

2.2 Other Standards:

(Surface preparations standards for Painting Steel Surface).
This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-in-charge.

2.2.1 DIN: 53151 Standards for Adhesion test.

2.3 The paint manufacturer's instructions shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

a) Instructions for storage to avoid exposure as well as extremes of temperature.

b) Surface preparation prior to painting.

c) Mixing and thinning.

d) Application of paints and the recommended limit on time intervals between coats.

3.0 SURFACE PREPARATION

3.1 Metal Surface Preparation

3.1.1 Safety

All work in adjacent areas, which may negatively affect the quality of blast cleaning, and/or impose safety hazards, must be completed or stopped before the blasting operation starts.
3.1.2 Pre-cleaning

Prior to surface preparation all weld spatter shall be removed from the surface, all sharp edges ground down and all surfaces cleaned free of contaminants including chalked paint, dust, grease, oil, chemicals and salt. All shop primed surfaces shall be water washed by means of suitable solvent, by steam cleaning, with an alkaline cleaning agent if necessary or by high-pressure water, to remove contaminants prior to top-coating.

3.1.3 Surface Decontamination

Surface decontamination shall be performed prior to paint application when uncoated surface is exposed to a corrosive environment or existing paint work is to be repaired.

Existing coatings shall be removed by abrasive blast cleaning, and then high pressure potable water shall be used to clean steel surfaces.

Prior to application of coatings, the surface shall be chemically checked for the presence of contaminants. A surface contamination analysis test kit shall be used to measure the levels of chlorides, iron salts and pH in accordance with the kit manufacturer’s recommendations.

Swabs taken from the steel surface, using cotton wool test swabs soaked in distilled water shall not be less than one swab for every 25m² of surface area to be painted.

Maximum allowable contaminant levels and pH range is as follows:

- Sodium chloride, less than 50 microgram / cm²;
- Soluble iron salts, less than 7 microgram / cm²; and

If the results of the contamination test fall outside the acceptable limits, then the wash water process shall be repeated over the entire surface to be painted, until the contaminant test is within the specified levels.

3.1.4 Abrasive Blasting

All C.S. materials shall be abrasive blast cleaned in accordance with Codes (Ref. Clause 2.0). To reduce the possibility of contaminating S.S., blasting is not usually specified. However, for coatings which require a blast-cleaned surface for proper adhesion, S.S. may be blast cleaned using clean aluminium oxide or garnet abrasives (Free from any chloride or Iron / Steel contamination). When hand or power tool cleaning is required on S.S., only S.S. wire-brushes (including 410 S.S.) which have not been previously used on C.S. surfaces may be used.

The surface profile of steel surfaces after blasting shall be of preparation grade Sa 2-1/2 of Swedish Standards SIS-05-5900 (Latest Revision) or better according to ISO 8501-1 and shall be measured using the replica tape method or the comparator method.

The roughness (profile) of blast-cleaned surfaces shall be Medium (G) according to ISO 8503-2: 1988 (appendix 1) unless otherwise specified. Medium defines a surface profile with a maximum peak-to-valley height of 60-100 microns, and G indicates that the surface profile is obtained by grit blasting. For the evaluation of surface roughness Comparator G shall be used.
Abrasive blast cleaning shall NOT be performed when the ambient or the substrate temperatures are less than 3°C above the dew point temperature. The relative humidity should preferably be below 50% during cold weather and shall never be higher than 60% in any case.

Abrasive blast cleaning shall be performed with a clean, sharp grade of abrasive. Grain size shall be suitable for producing the specified roughness. Abrasives shall be free from oil, grease, moisture and salts, and shall contain no more than 50ppm chloride. The use of silica sand, copper slag and other potentially silica containing materials shall not be allowed.

The blasting compressor shall be capable of maintaining a minimum air pressure of 7 kPa at the nozzle to obtain the acceptable surface cleanliness and profile.

The blast cleaning air compressor shall be equipped with adequately sized and properly maintained oil and water separators. The air supply shall be checked to ensure no oil and water contamination at the beginning of each work shift.

Blast cleaning abrasive shall be stored in a clean, dry environment at all times. Recycling of used abrasive is prohibited.

After blast cleaning, the surfaces shall be cleaned by washing with clean water (Pressure 7kg/Cm² using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matter.

Assessment of the blast cleaned surfaces shall be carried out in accordance with reference code.

Blast cleaned surfaces which show evidence of rust bloom or that have been left uncoated overnight shall be re-cleaned to the specified degree of cleanliness prior to coating.

All grit and dust shall be removed after blasting and before coating application. Removal shall be by a combination of blowing clean with compressed air, followed by a thorough vacuum cleaning with an industrial grade, heavy duty vacuum cleaner.

All cleaned surfaces shall have protection from atmospheric corrosion as per IS8629:1977

### 3.1.5 Alternate Methods of Surface Preparation

When open air blasting is not permitted on site, or when space limitations or surface configurations preclude blasting, the alternate cleaning methods listed below may be used with prior approval. Alternate cleaning methods shall consider the degree of surface cleanliness and roughness profile required by the specified coating system.

- Vacuum or suction head abrasive blast-cleaning,
- Wet jet abrasive blast-cleaning,
- Compressed-air wet abrasive blast cleaning,
- Pressurized liquid blast-cleaning,
- Power tool cleaning,
- Hand or power tool cleaning,

Hand and/or power tool cleaning shall only be used for spot repair where abrasive blasting is not permitted or is impractical, and on items which could be damaged by abrasive blasting. Power tool cleaning shall not be carried out with tools which polish the surface, e.g. power wire brushes.
The surfaces of equipments and prefabricated piping etc. which are received at site Primerised or with finish paints, depending upon their conditions, shall be touched up and painted at site. For these surfaces sand blasting is not envisaged and these surfaces shall be prepared using power brushes, buffing or scraping, so as to achieve a surface finish to St-3 as per SIS-05-5900. After wash-up the area to be touched up shall be jointly marked, measured and recorded for payment purposes. The type of system & nos. of coat (primer and/or finish paint) to be applied after touch up, which shall be decided by OWNER/CONSULTANT in writing before taking up the job.

When paint is to be applied on damaged painted surfaces of equipments all loose and flaking paint work should be removed to a firm feathered edge. Rusted spots should be cleaned by one of the methods specified in the clauses 4.4.1 & 4.4.2 above. In case the previous paint work is not compatible to the specified one the entire coating must be removed.

It shall be ensured that sand blasted surface/machine cleaned surface is not contaminated with oil and grease. Water shall also not be allowed to come in contact with sand blasted surface.

### 4.0 APPLICATION

#### 4.1 General

The final specification of paint systems to be used to suit the exposure conditions of equipment and steelwork, shall be as specified on the scope of work, equipment data sheets or the drawings.

All coatings shall be in accordance with Indian / International Standards, the coating manufacturer’s product data sheets and application instructions and the requirements contained in this specification.

#### 4.1.1 General Requirements for Shop Application

All work areas which facilitates shop paint application shall be surface prepared for painting and have the paint system applied before installation. Equipments assembled at site shall only receive primer coat in the shop and finish coatings will be applied at site.

In all cases, where surfaces will be inaccessible after shop assembly, they shall be prepared and have the paint system applied before assembly is carried out. Drying times between successive coats shall be at least those recommended by the manufacturer.

All known field weld areas shall be given the specified abrasive blast surface preparation but left uncoated for a distance of 50mm from the weld line. Such areas shall be given the appropriate touch-up treatment after installation.

The manufacturer's directions for preparation and application of coatings shall be followed to ensure that the durability of the coating system is not impaired.

The Contractor shall submit the full details of the proposed surface preparation and paint systems prior to the commencement of any surface preparation.

#### 4.1.2 General Requirements for Site Application

Paint shall be stored only in accordance with the manufacturer's instructions.
All materials used for the specific system being applied shall be products supplied by one manufacturer and details of such product shall be submitted for approval before commencement of work.

The contents of cans shall be thoroughly stirred before being poured into paint pots and shall be thinned only in the specified proportions in accordance with the manufacturer's instructions.

Finish coats may be applied by spraying except where any over spray is likely to affect finished surfaces or where spraying constitutes a health hazard to workmen in the other areas. Brush and roller application will require multiple coats to achieve the specified dry film thickness.

Brush application may be used only with the approval of the company.

Roller application shall only be used on relatively large surface areas (i.e. > 50m²) and only if spraying is not an option.

The Contractor shall complete the application of any one type of paint or each coat thereof, before beginning the next coat on that section.

In cases nominated as critical, the application of each coat shall be approved before application of the next coat can proceed, in accordance with 'hold' points nominated in the Inspection and Test Plans (ITPs)

All fittings within any given area are to be painted with the same system as the area unless otherwise specified.

Where 2 coat of finish paint are indicated they shall be applied in two different shades to ensure that two coat are applied.

Paint shall not be applied in rain, snow, fog or mist or when the relative humidity is such as to cause condensation on metal surface.

The CONTRACTOR must ensure the availability of a specialist from the paint manufacturer, at SITE during pendency of CONTRACT within his quoted rates to ensure the quality of painting & procedure. Addition of drying agents, pigments or other substances is not allowed unless specifically prescribed or approved by paint manufacturer's specialist.

Name plates/tags attached to the equipments/machineries shall not be painted or removed during painting job. Failing to comply with above, the CONTRACTOR may be required to replace name plates/tags at his cost.

4.1.3 Qualifications and Materials

All surface preparation, coatings application and inspection, shall be carried out by personnel experienced in that particular field. Contractors shall submit the names of subcontractors to be employed for the specific work together with the brand names of coating materials for approval prior to commencement of application.

4.1.4 Handling and Transport
All pipe work, steelwork and equipment that have been finish coated shall be handled with care to preserve the coating in the best practical condition.

Painted materials shall not be handled until the coating has completely cured and dried hard. Supports in contact with coated steel during transport and storage shall be covered with a soft material to prevent damage to the coating. Appropriate materials shall be used during transportation between coated steelwork and holding down chains to prevent damage to the coating.

### 4.2 Application of Coatings

#### 4.2.1 General

The application method and type of equipment to be used shall be suitable for the paint specified and the surface being painted.

Paints and thinners shall be brought to the point of usage in unopened original containers bearing the manufacturer's brand name and colour designation and ready-mixed unless otherwise specified. Two-pack systems shall be mixed at the site of application to the paint manufacturer's recommendations. The mixed amount prepared shall be no more than the amount that can be applied during the stated pot life.

Paint shall be applied so that an even film of uniform thickness, tint and consistency covers the entire surface and is free of pin holes, runs, sags or excessive brush marks. Film finish shall be equal to that of first class brushwork. Unless it is practical to do so, colour shades for primer, intermediate coat and finish coat must be different to identify each coat without any ambiguity.

Paint ingredients shall be kept properly mixed during paint application.

Equipment shall be kept clean to ensure dirt, dried paint and other foreign materials are not deposited in the paint film. Any cleaning solvents left in the equipment shall be completely removed before painting. To ensure the required film thickness is achieved on angles, welds, sharp external edges, nuts and bolts, a coat shall be applied to such items/locations immediately prior to the application of each coating to the whole area.

Care shall be taken to ensure paint application into all joints and crevices.

The contact surfaces between steelwork to be fastened by means of friction grip bolting shall be abrasive blast cleaned and prime coated only, prior to erection.

#### 4.2.2 Atmospheric conditions

Surface preparation and coating shall not be carried out in inclement weather and shall be carried out such that the surface being coated is free of moisture, wind-borne or blast cleaning dust.

Coatings shall not be applied if:

- The relative humidity exceeds 85%.
- The ambient temperature is less than 5°C (depending on local condition)
- The metal temperature is less than 3°C above the dew point.
- There is likely hood of an unfavourable change in weather conditions within two hours after painting.
As a general rule, sufficient ventilation, dehumidification and heating capacity to cope with local climatic conditions must be secured before any coating-related work is started.

In any case, humidity, ambient and surface temperature conditions at the time of paint application, and curing and drying time before application of the next coat, shall be in accordance with the paint manufacturer’s recommendations. These conditions shall be recorded in the Inspection Test Record (ITR) by the Contractor and be available for review.

4.2.3 Conventional or Airless Spray

Spray equipment shall be equipped with accurate pressure regulators and gauges. Spray gun nozzles and needles shall be those recommended by the paint manufacturer.

Air from the spray gun shall be clean and dry with no traces of oil or moisture.

Coatings shall be wet on contacting the painted surface. Areas of dry spray shall be removed and the correct system re-applied.

4.2.4 Brush Application

The method of "laying-off" shall be suited to the paint specified and shall ensure minimum brush marking.

4.2.5 Roller Application

A uniform method of application shall be adopted when painting large areas. The rolling direction shall minimise paint joint build up. Edges and areas subject to possible roller damage shall be brush-painted prior to rolling.

4.2.6 Thickness of Coatings

The maximum thickness DFT in any one application shall not exceed that specified in Technical specifications/recommended by the paint manufacturer.

Wet film thickness gauges shall be used to make frequent checks on the applied wet film. The Contractor shall maintain at the site of painting operations, a dry film thickness tester of an approved type with a valid current calibration.

Coating thickness checks in accordance with reference code shall be performed, and the Contractor shall undertake remedial action if the measured thickness is less than specified.

Build up of each material to required thickness shall be made prior to the application of the subsequent coat; final film build shall be the minimum specified.

4.2.7 Multiple Coat Applications (Except Wet-On-Wet)

Before successive paint coats are applied, intermediate coats shall be inspected for surface contamination. The presence of any grease or oil, shall be removed by a suitable solvent, and any salt and dirt adhering to the surface shall be removed by scrubbing with a solution of non-toxic detergent (except those prescribed by the manufacturer as "wet-on-wet"). Removal of contaminants shall only be performed after an intermediate coat has had sufficient time to cure.
The surface shall then be pressure hosed or dusted down by brush to disturb and remove deposits not apparent on visual inspection.

Coatings shall be applied only under the following conditions:
- The surface has been cleaned and is dry;
- The manufacturer's stated minimum time for re-coat has elapsed;
- The manufacturer's stated maximum time for re-coat has not elapsed. If the maximum time has elapsed then pre-treatment shall be in accordance with the paint manufacturer's recommendations; and
- Damaged areas in preceding coat have been made good in accordance with this Specification.

When multiple coat of finish paint are indicated, they shall be applied in different shades to ensure that multiple coats have been applied.

4.2.8 Protective Coatings for Fasteners

Black and galvanised erection bolts/nuts and galvanised holding down bolts/nuts shall be prepared and painted in accordance with Section 4.4 of this Specification.

Black high tensile bolts/nuts shall be painted after erection to the same paint system specification as the surrounding structural steel.

4.3 Hot Dip Galvanising

All galvanising shall be carried out by the hot dipping process and conform to the requirements of IS-2629:1985 and uniformity of coating shall confirm to IS 2633:1986.

All welding slag shall be removed by chipping, wire brushing, flame cleaning or abrasive blast cleaning where necessary prior to galvanising.

For temporary identification, either water-soluble marking paints or detachable metal labels shall be used. For permanent identification, figures/labels shall be heavily punched or embossed by the fabricator.

For galvanised items after pickling, the work shall be inspected and any defects that render the work unsuitable for galvanising shall be repaired. After such repairs, the work shall again be cleaned by pickling.

The coating mass of zinc shall be as specified on equipment data sheets and the Drawings. Galvanised coatings shall be tested by the methods described in referred code.

After galvanising all material shall be cooled to air temperature in such a manner that no embrittlement occurs.

Galvanised coatings shall be smooth, uniform, adherent and free from stains, surface imperfections and inclusions.
All gratings and fixtures including nuts, bolts and washers that are required to be galvanised, shall be hot dipped galvanised and all nut threads shall be re-tapped after galvanising and a lubricant applied on Cold working of galvanised steelwork shall be avoided.

4.4 Damaged or Inaccessible Surfaces

4.4.1 Damaged Paint Surface

Repair of damaged painted surfaces, as well as painting of galvanised and black bolts, and galvanised holding down bolts after erection shall comply with this Clause. The treatment shall be:

- Pre-clean the damaged or unpainted areas in accordance with Section 4.2.1 of this Specification;
- Disc or hand sand to clean bright metal;
- Inorganic zinc primers subject to mechanical damage or weld etc shall be power tool cleaned;
- Feather backs by sandpapering or whip blasting the original coatings surrounding the damaged area over a 50mm distance. A rough surface shall be obtained on epoxy coatings;
- Clean surface to remove all dust;
- Conduct surface contaminant test in accordance with Section 4.2.2 of this document; and
- Build up a new paint system over the affected area with paints equal to those originally used and having the same dry film thickness for each coat. As an exception, damaged inorganic zinc primers shall be repaired with epoxy organic zinc rich paint and shall be applied within four hours of blast cleaning.

The new coatings shall overlap the original coating over the 50mm prepared distance and shall be colour matched to the specified colour of the original coating.

4.4.2 Damaged Galvanised Surfaces

Damaged areas caused by oxy-cutting, welding or physical impact shall be treated as follows:

- Prepare the surface by removing any weld slag followed by vigorous power wire brushing of the coating surrounding the damaged area over a 50mm distance;
- Clean surface to remove all dust; and
- Apply two coats of organic zinc-rich primer to a minimum DFT of 100 microns.

The area to be reinstated shall be colour matched to the surrounding finish colour with 40 microns of aluminium paint to the manufacturer's written instructions.

4.4.3 Inaccessible Surfaces

Surfaces that will be inaccessible after erection of other elements of the structure, shall be fully painted prior to the installation of the obstructing item.

4.5 Surfaces Not To Be Coated

The following surfaces shall not be blasted or coated unless specifically directed:

Machined surfaces, bearings, seals, grease fittings, adjusting screws and name plates, and identification tags.

- Valve stems;
- Raised faces on pipe and equipment flanges;
- Electrical cabling;
- Instrumentation, gauges and sight glasses;
- Titanium, stainless steel and non-metallic surfaces; and

Field weld margins, 50mm either side of weld, on tankage and piping, prior welding.

The rear face of piping flanges shall be shop prime coated only. Flange holes for fasteners shall be fully coated.

4.6 Wash-Up

All surface of equipments/prefabricated piping etc. Primerised / painted at Vendor shop and received at site if required shall be washed up as follow:

a) Washing with clean water (Pressure 7 Kg/cm2) using suitable nozzles. During washing, broomcorn brushes shall be used to remove foreign matter.

b) Solvent washing, if required, to remove traces of wash up as per above procedure of all surfaces of equipment, piping, structure etc. completely painted at contractor's shop shall be included in the quoted rates of oil, grease etc. Wash up as per above procedure of all surfaces of equipment, piping, structure etc. completely painted at contractor's shop shall be included in the quoted rates.

4.7 Touch-Up Painting

Prior to the application of any coat, all damage to the previous coat(s) shall be touched-up. Damage to finished work shall be thoroughly cleaned and re-coated.

Surface preparation shall be done as per clause no. 3.0.........................

Items supplied with the manufacturer's standard coating system shall be touched-up with the same generic coating system or recoated.

4.8 Paint Storage

The following must be ensured:

a) All paints and painting material shall be stored only in such rooms assigned for the purpose. All necessary precaution shall be taken to prevent fire. The Storage building shall preferably be separate from adjacent buildings. A sign-board bearing the Words "PAINT STORAGE- NO NAKED LIGHT" shall be clearly displayed outside. The building shall be properly ventilated and shall be adequately protected with fire fighting equipment.

b) Storage shall be far away from heated surface open flames, sparks & well protected from sun rays.

c) Ambient temperature at which paints are stored shall be intimated to paint manufacturer & their advice sought regarding precautions to be taken if any, regarding flammability, explosiveness & toxicity.

d) Maximum allowed storage time for various paint materials shall be clearly indicated on individual containers. Materials which have passed expiry date shall not be used.

e) Paints in non-original containers and/or in containers without seals, shall not be used.
5.0 COATING SYSTEM SELECTION

Coating Systems for Structures Piping and Equipment

The following Table 1 shall be used as a general guide for the selection of a paint system suitable for a particular plant area application. Paint systems specified on equipment data sheets and the Drawings shall take precedence over the general paint system area applications listed in Table 1.

<table>
<thead>
<tr>
<th>Ref No.</th>
<th>Application</th>
<th>Surface Preparation</th>
<th>Generic Coating System</th>
<th>Minimum DFT</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Structural Steel work with operating temp. Up to 90°C (Steel structures, Piping support, uninsulated CS piping, flanges, valves, stairways, walkways etc. except grating).</td>
<td>Blast cleaning to near white metal grade 2½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1 F1 : One coat of two packs. Polyamide Cured Epoxy. F5 : One coat of two pack aliphatic acrylic polyurethane</td>
<td>P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns</td>
<td>Total dry film thickness of paint system: 240 microns as per C4 – High durability Total dry film thickness of paint system: 320 microns as per C5 – High durability</td>
</tr>
<tr>
<td>02</td>
<td>Uninsulated CS piping, flanges, valves with operating temp. From Above 90°C to 200°C.</td>
<td>Blast cleaning to near white metal grade Sa-2½, of Swedish Standards SIS-05-5900 (Latest)</td>
<td>P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleo resinous based heat resistant ready mixed Aluminium Paint.</td>
<td>P1 : 75 microns F3 : 2 x 25 microns for each coat Total - 125 microns.</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
<tr>
<td>04</td>
<td>Insulated CS piping flanges, valves with operating temp up to 90°C</td>
<td>Blast cleaning to near white metal grade 2½, of Swedish Standards SIS-05-5900</td>
<td>F8 : One coat of high temperature epoxy phenolic</td>
<td>F8 : 2 x 125 microns</td>
<td>Total dry film thickness of paint system: 250 microns.</td>
</tr>
<tr>
<td>Ref No.</td>
<td>Application</td>
<td>Surface Preparation</td>
<td>Generic Coating System</td>
<td>Minimum DFT</td>
<td>Remarks</td>
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</tr>
<tr>
<td>05</td>
<td>Insulated CS piping, flanges, valves with operating temp. From 90º C to 200º C.</td>
<td>Blast cleaning to near white metal grade Sa-2½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>F8 : Two coats of high temperature epoxy phenolic (novolac)</td>
<td>F8 : 2 x 125 microns</td>
<td>Total dry film thickness of paint system: 250 microns</td>
</tr>
<tr>
<td>06</td>
<td>Insulated CS piping, flanges, valves with operating temp. Over 200º C.</td>
<td>Blast cleaning to near white metal grade 2½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>F9 : Two coats of Inorganic Co-polymer based coating With an Inert Multipolymer Matrix.</td>
<td>F9 : 2 x 150 microns</td>
<td>Total dry film thickness of paint system: 300 microns</td>
</tr>
<tr>
<td>07</td>
<td>Uninsulated CS equipment with operating temp. Up to 90º C, to be treated at Manufacturer's shop.</td>
<td>Blast cleaning to near white metal grade 2½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1 F1 : One coat of two packs. Polyamide Cured Epoxy. F5 : One coat of two pack aliphatic acrylic polyurethane</td>
<td>P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns</td>
<td>Total dry film thickness of paint system: 240 microns as per C4 – High Durability Total dry film thickness of paint system: 320 microns as per C5 – High Durability</td>
</tr>
<tr>
<td>08</td>
<td>Uninsulated CS equipment with operating temp. From 91º C to 200º C, to be treated at Manufacturer's shop.</td>
<td>Blast cleaning to near white metal grade 2½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleo-Resinous based heat resistant ready mixed Aluminium Paint.</td>
<td>P1 : 75 microns F3 : 2 x 25 microns for each coat</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
<tr>
<td>09</td>
<td>Uninsulated CS equipment with operating temp. Over 200º C, to be treated at Manufacturer’s</td>
<td>Blast cleaning to near white metal grade 2½, of Swedish Standards SIS-05-5900</td>
<td>P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F4 : Two coats of Heat</td>
<td>P1 : 75 microns F4 : 2 x 25 microns for each coat</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
<tr>
<td>Ref No.</td>
<td>Application</td>
<td>Surface Preparation</td>
<td>Generic Coating System</td>
<td>Minimum DFT</td>
<td>Remarks</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Resisting Silicon Aluminium Paint.</td>
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</tr>
<tr>
<td>10</td>
<td>Insulated CS equipment with operating temp. Up to 90°C, to be treated at Manufacturer's shop.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>F8 : Two coats of high temperature epoxy phenolic (novolac) for each coat</td>
<td>F8 : 2 x 125 microns</td>
<td>Total dry film thickness of paint system: 250 microns</td>
</tr>
<tr>
<td>11</td>
<td>Insulated CS equipment with operating temp. From 91°C to 200°C, to be treated at Manufacturer's shop.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>F8 : Two coats of high temperature epoxy phenolic (novolac) for each coat</td>
<td>F8 : 2 x 125 microns</td>
<td>Total dry film thickness of paint system: 250 microns</td>
</tr>
<tr>
<td>12</td>
<td>Insulated CS equipment with operating temp. Over 200°C, to be treated at Manufacturer's shop.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>F9 : Two coats of Inorganic Co-polymer based coating With an Inert Multipolymer Matrix for each coat</td>
<td>F9 : 2 x 150 microns</td>
<td>Total dry film thickness of paint system: 300 microns.</td>
</tr>
<tr>
<td>13</td>
<td>Surface of structural steel for furnaces, external surface of furnaces, external surface of flue duct, metal stacks and similar with operating temp. Up to 200°C. (With exclusion of stair ways, walk ways etc.).</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 for each coat</td>
<td>P1 : 75 microns</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
<tr>
<td>14</td>
<td>For external surfaces of flue ducts, metal stacks, and similar with</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 for each coat</td>
<td>P1 : 75 microns</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
</tbody>
</table>
### STEAM GENERATION PLANT
**TALCHER FERTILIZERS LIMITED**
**CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP**

<table>
<thead>
<tr>
<th>Ref No.</th>
<th>Application</th>
<th>Surface Preparation</th>
<th>Generic Coating System</th>
<th>Minimum DFT</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>For surfaces of air cooler heads not galvanized with operating temperature up to 90°C, treated at manufacturer's shop.</td>
<td>Blast cleaning to near white metal grade 2½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1</td>
<td>P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns</td>
<td>Total dry film thickness of paint system: 240 microns as per C4 – High Durability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1</td>
<td>P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns</td>
<td>Total dry film thickness of paint system: 240 microns as per C4 – High Durability</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F1 : One coat of two packs. Polyamide Cured Epoxy.</td>
<td>P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1</td>
<td>P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns</td>
<td>Total dry film thickness of paint system: 240 microns as per C4 – High Durability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F5 : One coat of two pack aliphatic acrylic polyurethane</td>
<td>P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1</td>
<td>P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns</td>
<td>Total dry film thickness of paint system: 240 microns as per C4 – High Durability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NOTE: All surfaces shall be galvanized at manufacturer’s shop with exception of the end header of air cooled heat exchangers that shall be treated as described above at Manufacturer’s shop. In case the same surfaces shall not be treated at shop, they shall be treated at site according to environmental and operating conditions.</td>
<td>P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1</td>
<td>P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns</td>
<td>Total dry film thickness of paint system: 240 microns as per C4 – High Durability</td>
</tr>
<tr>
<td>16</td>
<td>For surfaces of air cooler heads not galvanized with operating temperature up to 91°C to 200°C, treated at manufacturer’s shop.</td>
<td>Blast cleaning to near white metal grade 2½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleouresinous based heat resistant ready mixed Aluminium Paint.</td>
<td>P1 : 75 microns F3 : 2 x 25 microns for each coat</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleouresinous based heat resistant ready mixed Aluminium Paint.</td>
<td>P1 : 75 microns F3 : 2 x 25 microns for each coat</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>NOTE: All surfaces shall be galvanized at manufacturer’s shop with exception of the end header of air cooled heat exchangers that shall be treated as described above at Manufacturer’s shop. In case the same surfaces shall not be treated at shop, they shall be treated at site according to environmental and operating conditions.</td>
<td>P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleouresinous based heat resistant ready mixed Aluminium Paint.</td>
<td>P1 : 75 microns F3 : 2 x 25 microns for each coat</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
<tr>
<td>18</td>
<td>STORAGE TANKS</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>a)</td>
<td>Acid / Alkali CS Storage Tank (External Surface)</td>
<td>Blast cleaning to near white metal grade 2½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1</td>
<td>P2 : 60 microns F1 : 120 – 200 microns</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
<tr>
<td>Ref No.</td>
<td>Application</td>
<td>Surface Preparation</td>
<td>Generic Coating System</td>
<td>Minimum DFT</td>
<td>Remarks</td>
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<tr>
<td></td>
<td>including all stair ways</td>
<td>Standards SIS-05-5900 (Latest).</td>
<td>F1: One coat of two packs. Polyamide Cured Epoxy. F5: One coat of two pack aliphatic acrylic polyurethane</td>
<td>200 microns F5 : 60 microns</td>
<td>system: 240 microns as per C4 – High Durability system: 320 microns as per C5 – High Durability</td>
</tr>
<tr>
<td>b)</td>
<td>CS Storage Tanks, Excluding indicated in Sl. No. (a)</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>P1: One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F1: One coat of two pack Polyamide Cured Epoxy. F5: Two-pack aliphatic Isocyanate cured acrylic finish paint</td>
<td>P1 : 60 microns F5 : 60 microns</td>
<td>Total dry film thickness of paint system: 240 microns as per C4 – High Durability Total dry film thickness of paint system: 320 microns as per C5 – High Durability</td>
</tr>
<tr>
<td>19</td>
<td>Cold Insulated Carbon Steel and low alloy Steel (1-1/4 Cr through 9 Cr) Piping and Equipment (Upto 60 Deg. C)</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>F7: Two coats of Tar Free Epoxy paint suitably pigmented</td>
<td>P1 : 60 microns F1 : 120 - 200 microns F5 : 60 microns</td>
<td>Total dry film thickness of paint system: 250 microns.</td>
</tr>
<tr>
<td>20</td>
<td>Cold Insulated high alloy Steel piping and Equipment (Upto 200 Deg. C)</td>
<td>Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest).</td>
<td>F8: Two coats of high temperature epoxy phenolic (novolac)</td>
<td>F8 : 2 x 125 microns</td>
<td>Total dry film thickness of paint system: 250 microns.</td>
</tr>
<tr>
<td>21</td>
<td>DELETED</td>
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</tr>
<tr>
<td>22</td>
<td>Surface (CS) with Equipment with temp. Indicating paint from 220°C to 240°C treated at Manufacturer’s shop</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F6 : Temperature indicating paint</td>
<td>P1 : 75 microns F6 : 2 x 25 microns for each coat Total - 50 microns</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
<tr>
<td>23</td>
<td>PACKAGE:</td>
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</tr>
<tr>
<td>Ref No.</td>
<td>Application</td>
<td>Surface Preparation</td>
<td>Generic Coating System</td>
<td>Minimum DFT</td>
<td>Remarks</td>
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<td>---------------------------------------------</td>
</tr>
<tr>
<td>a)</td>
<td>Surface(CS) with operating temperature upto 90°C treated at Manufacturer’s shop</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1</td>
<td>P2 : 60 microns</td>
<td>Total dry film thickness of paint system:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>F1 : One coat of two packs. Polyamide Cured Epoxy.</td>
<td>F1 : 120 – 200 microns</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>F5 : One coat of two pack aliphatic acrylic polyurethane</td>
<td>F5 : 60 microns</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>b)</td>
<td>Surfaces (CS) with operating temperature upto 91°C TO 200°C, treated at manufacturer’s shop.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1</td>
<td>P1 : 75 microns</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>F3 : Two coats of single pack special Oleouresinous based heat resistant ready mixed Aluminium Paint.</td>
<td>F3 : 2 x 25 microns for each coat</td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td>Surface (CS) with operating temp. Over 200°C, treated at manufacturer’s shop.</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1</td>
<td>P1 : 75 microns</td>
<td>Total dry film thickness of paint system: 125 microns.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>F4 : Two coats of Heat Resisting Silicon Aluminium Paint.</td>
<td>F4 : 2 x 25 microns for each coat</td>
<td></td>
</tr>
<tr>
<td>d)</td>
<td>Package in Carbon Steel and low Alloy Steel (1-1/4 Cr through 9 Cr) with cold insulated surface treated at manufacturer’s shop (Upto 60 Deg. C)</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>F7 : Two coats of Tar Free Epoxy paint suitably pigmented</td>
<td>F7 : 2 x 125 microns</td>
<td>Total dry film thickness of paint system: 250 microns.</td>
</tr>
<tr>
<td>e)</td>
<td>Package in Cold Insulated high alloy Steel. (Upto 200 Deg. C)</td>
<td>Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-</td>
<td>F8 : Two coats of high temperature epoxy phenolic (novolac)</td>
<td>F8 : 2 x 125 microns</td>
<td>Total dry film thickness of paint system: 250 microns.</td>
</tr>
<tr>
<td>Ref No.</td>
<td>Application</td>
<td>Surface Preparation</td>
<td>Generic Coating System</td>
<td>Minimum DFT</td>
<td>Remarks</td>
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</tr>
<tr>
<td></td>
<td>f) DELETED</td>
<td></td>
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</tr>
<tr>
<td>24</td>
<td>For internal surface of shell, roof of CS tanks, with operating temp. Upto 110°C</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>F2 : Two coats of two pack amine adduct cured Phenolic (Novolac) epoxy (immersion grade)</td>
<td>F2 : 2 x 150 microns for each coat</td>
<td>Total dry film thickness of paint system: 300 microns.</td>
</tr>
<tr>
<td>25</td>
<td>For underside (soil side) of the tank bottom (CS) below only of the fixed tanks, bottom &amp; shell shall be treated as follows:</td>
<td>Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>F7 : Two coats of Tar Free Epoxy paint suitably pigmented OR F8 : Two coats of high temperature epoxy phenolic (novolac)</td>
<td>F7 : 2 x 200 microns OR F8 : 2 x 150 microns</td>
<td>Total dry film thickness of paint system: 400 microns. OR Total dry film thickness of paint system: 300 microns.</td>
</tr>
<tr>
<td>26</td>
<td>CS Equipment and associated piping subject to cyclic, intermittent or regeneration operating condition (e.g. Molecular Sieve Driers) subjected to very severe corrosion with wide operating temperature range.</td>
<td>Blast cleaning to near white metal grade 3, of Swedish Standards SIS-05-5900 (Latest).</td>
<td>Primer: One coat of Thermal spray Aluminium paint and sealed with a Silicon Aluminium seal Finish Coat: One coat of Thermal spray Aluminium paint and sealed with a Silicon Aluminium seal.</td>
<td>Primer: 125 microns Finish: 125 microns</td>
<td>Total dry film thickness of paint system 250 microns.</td>
</tr>
</tbody>
</table>

**NOTES:**

**Primers**

**ZINC ETHYL SILICATE PRIMER – P1**

The zinc ethyl silicate consists of two packs. One pack contains the ethyl silicate binder with suitable solvents. The other pack contains zinc dust (NOT Paste). Zinc dust shall be ASTM D 520 Type II. They have to be mixed in suitable proportions before application as recommended by manufacturer.

| Volume solids | Min.64% ±2 |
Zinc silicate Material curing shall be checked using ASTM D 4752, minimum Acceptable value is 4.

**ZINC RICH EPOXY PRIMER – P2**
The zinc rich epoxy consists of two packs. One pack contains the epoxy binder with suitable solvents. The other pack contains zinc dust as per ASTM D520 Type II. They have to be mixed in suitable proportions before application as recommended by manufacturer.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume solids</td>
<td>65% min. ±2</td>
</tr>
<tr>
<td>DFT</td>
<td>50 – 100 microns</td>
</tr>
<tr>
<td>Theoretical Spreading Rate</td>
<td>13 – 6.5 sqm/litre</td>
</tr>
<tr>
<td>Colour</td>
<td>Grey</td>
</tr>
<tr>
<td>Application</td>
<td>Airless spray/air spray/brush</td>
</tr>
<tr>
<td>Drying time ( dry to handle )</td>
<td>&lt;10 min. @ 30 Deg C</td>
</tr>
<tr>
<td>Harden Dry</td>
<td>&lt; 1.5 hrs @ 30 Deg C</td>
</tr>
<tr>
<td>% of total metallic zinc in dry film (As per the ASTM D520 – Spherical size)</td>
<td>(SSPC SP 20 Level 2) 81% by wt. min.</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>2.3 Kg/Litre min.</td>
</tr>
<tr>
<td>Storage life</td>
<td>12 months under sealed conditions</td>
</tr>
</tbody>
</table>

Finish Paints

**HIGH BUILD EPOXY FINISH – F1**
This finish paint is fast drying, high build, Two-pack polyamide cured epoxy resin

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume solids</td>
<td>85% min. ±2</td>
</tr>
<tr>
<td>DFT Range</td>
<td>100 – 200 microns</td>
</tr>
<tr>
<td>Theoretical Spreading Rate</td>
<td>7.6 – 3.8 sqm/litre</td>
</tr>
<tr>
<td>Colour</td>
<td>As per Manufacturer List</td>
</tr>
<tr>
<td>Binder</td>
<td>Polyamide cured epoxy resin, Lead &amp; Chrome Free</td>
</tr>
<tr>
<td>Application</td>
<td>Brush or spray</td>
</tr>
<tr>
<td>Drying time</td>
<td>&lt; 2 hrs @ 30 Deg C</td>
</tr>
<tr>
<td>Over coating time</td>
<td>&lt; 2 hrs @ 30 Deg C</td>
</tr>
<tr>
<td>Storage life</td>
<td>24 months under sealed conditions</td>
</tr>
</tbody>
</table>

**HIGH BUILD EPOXY FINISH (Immersion Grade) – F2**
This finish paint is high build, Two-pack phenolic (novolac) epoxy

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
</table>
### HEAT RESISTANT ALUMINIUM FINISH PAINT : F3

It is a single pack system based on oleo resinous general purpose aluminium paint with good heat resistance up to 250 Deg. C. and light reflection.

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume solids</td>
<td>25% min. ±2</td>
</tr>
<tr>
<td>DFT Range</td>
<td>25 microns</td>
</tr>
<tr>
<td>Theoretical Spreading Rate</td>
<td>10 sqm/litre</td>
</tr>
<tr>
<td>Main pigment</td>
<td>Aluminium (ASTM 962), Lead &amp; Chrome Free</td>
</tr>
<tr>
<td>Colour</td>
<td>Metallic Aluminium</td>
</tr>
<tr>
<td>Pigment Volume Concentration</td>
<td>15 – 20%</td>
</tr>
<tr>
<td>Application</td>
<td>Brush or spray</td>
</tr>
<tr>
<td>Drying time</td>
<td>Surface dry &lt;1hr. @ 30 Deg. C</td>
</tr>
<tr>
<td></td>
<td>Hard dry &lt; 3 hrs. @ 30 Deg. C</td>
</tr>
<tr>
<td>Storage life</td>
<td>24 months under sealed conditions</td>
</tr>
</tbody>
</table>

### HEAT RESISTANT SILICON ALUMINIUM FINISH PAINT : F4

It is a single pack system based on ambient curing silicone aluminium pigmented polysiloxane paint with maximum heat resistance of up to 600 Deg. C.

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume solids</td>
<td>25% min. ±2</td>
</tr>
<tr>
<td>DFT Range</td>
<td>25 microns</td>
</tr>
<tr>
<td>Theoretical Spreading Rate</td>
<td>10 sqm/litre</td>
</tr>
<tr>
<td>Main pigment</td>
<td>Aluminium (ASTM 962), Lead &amp; Chrome Free</td>
</tr>
<tr>
<td>Property</td>
<td>Value</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Colour</td>
<td>Metallic Aluminium</td>
</tr>
<tr>
<td>Pigment Volume Concentration</td>
<td>15 – 20%</td>
</tr>
<tr>
<td>Application</td>
<td>Brush or spray</td>
</tr>
<tr>
<td>Drying time</td>
<td>Surface dry &lt; 1hr. at 30 Deg. C</td>
</tr>
<tr>
<td></td>
<td>Hard dry &lt; 3 hrs. at 30 Deg. C</td>
</tr>
<tr>
<td>Storage life</td>
<td>12 months under sealed conditions</td>
</tr>
</tbody>
</table>

**TWO PACK ALIPHATIC ACRYLIC POLYURETHANE FINISH PAINT – F5**

It consists of Acrylic Resin in Part A. Part B consists of an aliphatic poly-isocyanate with appropriate solvents and additives.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume solids</td>
<td>51% min. ±2</td>
</tr>
<tr>
<td>DFT range</td>
<td>50 – 100 microns</td>
</tr>
<tr>
<td>Theoretical Spreading Rate</td>
<td>10.2 – 5.1 sqm/litre</td>
</tr>
<tr>
<td>Main pigment</td>
<td>Suitable pigments to get the desired colour, Lead &amp; Chrome Free</td>
</tr>
<tr>
<td>Colour</td>
<td>Metallic Aluminium</td>
</tr>
<tr>
<td>Binder</td>
<td>Shall not contain any binder other than acryl / acrylate alkyds / esters.</td>
</tr>
<tr>
<td>Application</td>
<td>Brush or spray</td>
</tr>
<tr>
<td>Drying time</td>
<td>Surface dry &lt; 1hr. @ 30 Deg. C</td>
</tr>
<tr>
<td></td>
<td>Hard dry &lt; 8 hrs. @ 30 Deg. C</td>
</tr>
<tr>
<td>ISO 11507/ASTM G 154, QUV A</td>
<td>Gloss retention: approx. 80% and colour change approx. DE 1.2 after 3000 hours exposure</td>
</tr>
<tr>
<td>Accelerated weathering</td>
<td></td>
</tr>
<tr>
<td>Storage life</td>
<td>24 months under sealed conditions</td>
</tr>
</tbody>
</table>

**TEMPERATURE INDICATING PAINT : F6**

It is a single pack temperature indicating system based on silicone binder. Pigments change colour by heating. The colour change of the coating is permanent. At approximately 200°C, the colour changes from green to blue, above 310°C, the colour changes from blue to greyish white. Maximum service temperature is 400°C.
### Volume solids
- Minimum 72%

### DFT Range
- 150 – 200

### Theoretical Spreading Rate
- 4.8 – 3.6 sqm/litre

### Application
- By brush or airless spray

### Drying time
- Touch dry within 4 hrs. @ 30 Deg C
- Hard dry < 9 hours @ 30 Deg C

### Storage life
- 12 months under sealed conditions

---

**TAR FREE EPOXY – F7 (Coal Tar is Banned Globally being Carcenogic)**

A high build two component abrasion resistant, pure epoxy with anti-corrosive properties meant for excellent performance.

<table>
<thead>
<tr>
<th>Volume solids</th>
<th>Minimum 72%</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFT Range</td>
<td>150 – 200</td>
</tr>
<tr>
<td>Theoretical Spreading Rate</td>
<td>4.8 – 3.6 sqm/litre</td>
</tr>
<tr>
<td>Application</td>
<td>By brush or airless spray</td>
</tr>
<tr>
<td>Drying time</td>
<td>Touch dry within 4 hrs. @ 30 Deg C</td>
</tr>
<tr>
<td></td>
<td>Hard dry &lt; 9 hours @ 30 Deg C</td>
</tr>
<tr>
<td>Storage life</td>
<td>12 months under sealed conditions</td>
</tr>
</tbody>
</table>

---

**EPOXY PHENOLIC (NOVOLAC) – F8**

Two Pack epoxy-phenolic (novolac) cured with amine adduct used as an External coating for the protection of insulated (CUI) equipment.

<table>
<thead>
<tr>
<th>Volume solids</th>
<th>68% min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFT Range</td>
<td>100 – 150 microns</td>
</tr>
<tr>
<td>Theoretical Spreading Rate</td>
<td>6.8 – 4.5 sqm/litre</td>
</tr>
<tr>
<td>Binder</td>
<td>Epoxy phenolic (novolac)</td>
</tr>
<tr>
<td>Dry Temp. Service</td>
<td>Min. -196 to max. 205 Deg C</td>
</tr>
<tr>
<td>Application</td>
<td>Airless Spray / Brush Touch up</td>
</tr>
<tr>
<td>Drying Time</td>
<td>Surface dry &lt; 1.5hr. @ 30 Deg C</td>
</tr>
<tr>
<td></td>
<td>Hard dry &lt; 6 hours @ 30 Deg C</td>
</tr>
<tr>
<td>Storage life</td>
<td>12 months under sealed conditions</td>
</tr>
</tbody>
</table>

---

**INORGANIC CO-POLYMER COATING – F9**

---
MIO pigmented single component inorganic copolymer coating which cures to form an in-polymer matrix able to resist temperatures up to 650°C/1202°F and thermal shock/cycling dry or dry/wet service.

| Volume solids | 74% min. |
| DFT Range     | 150 microns |
| Theoretical Spreading Rate | 5 sqm/litre |
| Binder        | Inorganic copolymer coating |
| Dry Temp. Service | Min. -196 to max. 650 Deg. C. |
| Application   | Airless Spray / Brush Touch up |
| Drying Time   | Surface dry < 0.5hr. @ 30 Deg. C |
|               | Hard dry < 1.5 hours @ 30 Deg. C |
| Storage life  | 12 months under sealed conditions |

6.0 MACHINERY, ELECTRICAL AND INSTRUMENT EQUIPMENT:

6.1 Machinery

Steel surfaces shall be treated with complete paint system at Manufacturer's shop. The paint system shall be according to Manufacturer’s Std. However, suitable for operating condition and the environmental condition where the machinery will operate. Where necessary machinery shall be restored at site by Contractor with suitable finish.

6.2 Electrical and Instrument Equipment

Steel surfaces shall be treated with complete paint system at Manufacturer's shop. The paint system shall be according to Manufacturer’s Std., however suitable for operating condition and the environmental condition where the electrical and instrument equipment will operate. Where necessary Electrical and Instrument Equipment shall be restored at site by Contractor with suitable finish.

7.0 COLOURS:

These shall be as required by specification and in particular for:

<table>
<thead>
<tr>
<th>Description</th>
<th>Colour</th>
<th>Ra1</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Piping with temperature less than 90°C</td>
<td>GREY</td>
<td>7035</td>
</tr>
<tr>
<td>- Piping, hot surface, flue gas ducts and stacks with temperature above 90°C</td>
<td>SMOOTH</td>
<td>ALUMINIUM</td>
</tr>
<tr>
<td>- Cooling Water Piping</td>
<td>SEA GREEN</td>
<td></td>
</tr>
<tr>
<td>- Fire fighting Piping</td>
<td>Red</td>
<td>3002</td>
</tr>
<tr>
<td>- Structures upto 2 MT</td>
<td>BLACK</td>
<td>9005</td>
</tr>
<tr>
<td>- Structures above 2 MT</td>
<td>GREY</td>
<td>7010</td>
</tr>
</tbody>
</table>
### Description

<table>
<thead>
<tr>
<th>Description</th>
<th>Colour</th>
<th>Ra1</th>
<th>Correspond. Asian Paint colors to be defined – See Note-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Stair cases – ladders</td>
<td>BLACK 9005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Walkways</td>
<td>GREY 7010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Handrails assemblies</td>
<td>YELLOW 1004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Equipment</td>
<td>GREY 7035</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Hot equipment</td>
<td>SMOOTH ALUMINIUM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Fire fighting equipment</td>
<td>RED 3002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Valves in general</td>
<td>GREY 7035</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Hot valves</td>
<td>SMOOTH ALUMINIUM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Safety and Fire fighting valves</td>
<td>RED 3002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Valves handwheels</td>
<td>BLACK 9005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Electric Rotary Machines</td>
<td>SKY BLUE 5012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Electric Static Machines</td>
<td>GREY 7035</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Machinery (compressors &amp; pumps) with operating temperature less than 90°C</td>
<td>GREY 7035</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Machinery (compressors &amp; pumps) with operating temperature above 90°C</td>
<td>SMOOTH ALUMINIUM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### FURNACES

- Cassing and connected steel works                                      SMOOTH ALUMINIUM |
- Steel work not connected to casing                                      SMOOTH ALUMINIUM |

#### AIR COOLER

- High Temperature Surfaces (Temp. > 90°C)                                SMOOTH ALUMINIUM |
- Low Temperature surface (Temp. ≤ 90°C)                                  GREY 7035 |
- Flare ≤ 90°C                                                            GREY 7035 |
- Flare > 90°C                                                             SMOOTH ALUMINIUM |

#### TANKS

- Shell of fixed roof                                                     WHITE 9010 |
- Roof of fixed roof tank                                                 WHITE 9010 |

### NOTE-1:
The colours shall be according to IS2379:1990/International STD. RAL or BS, proposed by Contractor or Manufacturer

### 8.0 PARTICULAR DESCRIPTION

The abrasive Grit Blasting shall be used for surface preparation. **Sand blasting is prohibited due to environmental regulations.**
Primerized surface shall be faultless and shall not have mud-cracking, dripping over thickness and dry sprays.

Blast cleaning and painting shall not be carried out on wet surfaces.
Blast cleaning shall not be done when surfaces temperatures are less than 3°C above dew point, or temperature is below 5°C.

No acid washes or other cleaning solutions or solvents shall be used on metal surfaces after they have been blasted.

The surface preparation of all steel surfaces to be coated shall be free of all mill scale, rust corrosion product, oxides, paint, oil or other foreign matter

Only dry abrasive blasting procedures will be allowed. The compressed air supply used for blasting shall be free of detrimental amounts of water and oil. Adequate separator and traps shall be provided and these shall be kept emptied of water and oil. Any blast cleaning set up without functioning moisture separators shall be removed from blast cleaning areas.
All welded areas and appurtenances shall be given special attention for removal of welding flux in crevices. Welding splatter, slivers, laminations and underlying mill scale exposed during sand blasting shall be removed or repaired.

The blast-cleaned or power brushing surfaces shall be coated with primer within four hours of surface preparation.

No primer or intermediate or finishing coating shall be applied without prior notification to the Company.

The application of the products shall be carried out in strict compliance with the paint manufacturer’s recommendation.

The Contractor shall provide suitable protection for all adjacent plants or equipment from airborne during spraying and sand blasting.

9.0 INSPECTION AND TESTING
The inspection and testing requirements outlined in this section shall be performed for shop and site applied coating systems.

Preference shall be given to manufacturers and applicators that are quality certified to ISO 9001: 2000.

Documentation of coating material manufacturers and applicators shall include daily inspection reports, equipment reports, and shall clearly identify and trace materials supply and testing performed on coated items and areas.

Inspection and Test Plans (ITPs), and quality control procedures used for application of coating systems shall form part of the Method Statement and shall be submitted for approval by the Principal prior to commencement of work.

The applicator shall appoint a certified inspector of coatings for inspection and testing of coating systems.

Tests of coated areas and items shall form part of the ITPs.
Surface Preparation in accordance to Swedish Standard SIS-05-5900 (Latest).

Blast cleaning profile shall be checked using a suitable profile meter – Acceptable profile shall be 40 - 60 microns.

Check of time of top coating and drying in accordance with the direction of the paint manufacturer.

Check of dry film thickness by suitable non-destructive Instrument such as “MIKROTEST”, “DIAMETER” or equivalent.

Before any coating work is performed on the site, the contractor shall ensure that any works applied by others is acceptable.

Any defect that are discovered, are to be notified in writing to the owner before proceeding with the contract work. To ensure the good execution of painting work following test shall be performed:

- Surface Preparation
- Surface contaminant tests
- Surface profile tests
- Coating thickness tests
- Tests for cure of coatings
- Adhesion tests
- Continuity testing
- Iron contamination
- Chloride contamination
- Dust Contamination

All Inspection and Test Records (ITRs) shall be submitted with the Manufacturer’s Data Report (MDR) at the conclusion of the job.

Defective coated areas shall be suitably marked for rectification work to be performed in compliance with this specification.

Access shall be granted for inspection of all paint work, and witnessing of test work. This shall not however relieve the Contractor of their own QA/QC responsibilities.

10.0 ADHESION TEST RESULTS

For all type of primer the Contractor shall guarantee the Classification of Adhesion Test Results as per ASTM D3359. The acceptable Rate Adhesion Test Results shall be for sandblasted and primerized surfaces shall be minimum 3A (or Higher)

For primer plus finishing coat(s) the Contractor shall guarantee the Classification of Adhesion Test Results as per ASTM D 3359. The acceptable Rate Adhesion Test Results shall be for blast cleaned and painted surfaces shall be minimum 3A (or higher).

After test, the surface must be repaired according to the system applied.

11.0 SUBMISSION OF DATA

Contractor shall submit in phase of bid the original technical data sheet and system for all material supplied by him to apply for the permanent works and test report for the paint in compliance to IS101. This material shall be subject to Owner’s approval.

The test certificates of zinc silicate shall provide the specific gravity of mixed paint.

12.0 LETTER AND NUMBER INSCRIPTION
Inscriptions letters, as herebelow indicated, shall be made on equipments, piping, storage tanks, machinery etc.

12.1 Geometric forms and dimensions

Letters and numbers dimensions shall be orientativaly fixed according to following:

(A – Dimension of side of unitary elements of grid)

a) Storage Tanks A – 60 mm
b) Equipments and piping with O.D. above 600 mm A– 40 mm and
c) Equipments and pipings with O.D. from 300 to 600 mm and for machinery of great dimensions A – 20 mm
d) Equipments and pipings with O.D. less than 300 mm and for machinery with small dimensions A – 10 mm

12.2 Inscription’s Colours

Inscriptions shall be Black ENI 901 (RAL 9005) on light base

Inscriptions shall be White ENI 101 (RAL 9010) on dark base

12.3 Spaces and Interspaces

Spaces between words and assemblage of numbers shall have dimensions equal to 2A

Interspaces between letters or numbers shall have dimensions equal to A.

13.0 Colour Band for piping ;-

As a rule minimum width of colour band shall confirm to the following Table:-

<table>
<thead>
<tr>
<th>Nominal pipe Size</th>
<th>Width L (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3” &amp; below</td>
<td>25</td>
</tr>
<tr>
<td>4” NB-6” NB</td>
<td>50</td>
</tr>
<tr>
<td>8” NB-12”NB</td>
<td>75</td>
</tr>
<tr>
<td>14” OD &amp; above</td>
<td>100</td>
</tr>
</tbody>
</table>

14.0 LIST OF MANUFACTURERS :

1. M/s Berger Paints
2. M/s Jensons & Nickolson
3. M/s Jotun Paints
4. M/s Asian Paints
5. M/s Grauer & Weil (India) Limited
6. M/s Shalimar paints
7. M/s Garware Paints
8. M/s Goodlass Nerolac Paints Ltd
9. M/s HEMPEL Paints
10. M/s International Paints (Akzo Nobel Brand)
11. M/s Carboline (India) Pvt. Ltd.
12. M/s Mohan Paints

15.0 The contractor shall obtain prior approval from Engineer-In-Charge for the brands of paint material proposed to be used. The contractor shall submit the following details of paint material either at the time of bidding or soon after award of work for approval of paints.

a. Technical data sheet
b. Material safety data sheet
c. Finger printing of paint products as per ISO 20340

16.0 Owner reserves the right to take random samples and get it tested through reputed labs. In case the supplied paint material do not meet the specified performance requirements then suitable action shall be taken against the paint supplier. The decision of Engineer-In Charge shall be final and binding on the Contractor in such cases.

17.0 WARRANTY:
Contractor along with Paint Manufacturer jointly shall develop the paint schemes following the system specification.

They shall jointly provide a performance guarantee for a period 5 years as stipulated below,

After 1 years – Corrosion in 3% of total painted area accepted
After 2 years – Corrosion in 6% of total painted area accepted
After 3 years – Corrosion in 9% of total painted area accepted
After 4 years – Corrosion in 12% of total painted area accepted
After 5 years – Corrosion in 15% of total painted area accepted

where spontaneous visible corrosion has broken down the paint film to a degree exceeding “Ri 3” (as defined in ISO 4628/3-2003).
ANNEXURE- 7 - 3

QUALITY CONTROL PROCEDURE AND INSPECTION REQUIREMENTS

1.0 LSTK CONTRACTOR’S QUALITY CONTROL

1.1 LSTK CONTRACTOR shall provide a quality control program manual include specific WORK methods and inspections, which assure quality.

This quality control program manual must be submitted to OWNER for Approval before starting the construction activities.

All installation WORK must be in strict accordance with this approved manual.

1.2 The quality control program shall include as a minimum the following:

- Methods use to control drawings; specifications and CONTRACT correspondence to assure that only the latest revisions are being used in the field.
- Inspection personal name, organization.
- Inspection methods and documentation of inspection (or tests) for shop fabrication, if required, and installation.
- Material control procedures from SITE receiving point, through "over, short and damage inspection" through storage and through installation.
- Positive material identification Procedures for:
  - Electrical cable pulling and testing.
  - Asphalt placement inspection.
  - Handling and storage methods to prevent damage.
  - Inspection and testing procedures and reports for civil, structural, piping, electrical, instrument, equipment and all installation WORK.
  - Repair.
  - Scrap and reject.
  - Grouting.
  - Welding.
  - Welder qualification.
  - Receiving all permanent plant material & equipment.
  - Rigging.
  - Welder's tests.
  - Nondestructive examinations to be used.
  - Positive material identification. etc.
- Identification of LSTK CONTRACTORS and ensuring their compliance with the manual and WORK required.
- Material certification verification methods.
- Calibration procedures for measurements and test equipment.
- Marking and identification of components in process and complete assemblies.

2.0 Shop fabrication and field installation inspection OWNER'S REPRESENTATIVE to ensure specifications. in the following areas will be performed by full adherence to Receiving and inspection.

- Calibration of test inspection equipment.
- Preventive maintenance and storage protection.
- Internal cleanliness.
- Proper material use and control.
- Nondestructive testing and its results.
- Workmanship.

3.0 OWNER'S REPRESENTATIVE or others as authorized by OWNER are to be permitted access to LSTK CONTRACTOR'S work areas for the purpose of inspection of material, equipment, documentation and other areas as required in LSTK CONTRACTOR'S quality assurance / quality control program.

4.0 No concrete will be placed by LSTK CONTRACTOR without an OWNER "Pour Release Form'.

5.0 OWNER'S construction inspections will not relieve. LSTK CONTRACTOR of inspection or other responsibilities.

6.0 For piping all welders test pieces shall be supplied by LSTK CONTRACTOR and fully prepared for welding by LSTK CONTRACTOR.

7.0 LSTK CONTRACTOR shall evidence its familiarity and experience with the execution of the installation of WORK to the requirements of the applicable codes and shall perform its WORK in accordance to these requirements and to instructions issued by OWNER'S REPRESENTATIVE in this regard.

8.0 CHECK ON QUALITY OF WORK

8.1 OWNER'S REPRESENTATIVE'S inspector shall have free access to the place where the WORK is performed at all times, in order to check the quality of WORK.

8.2 If during inspection / check reveals unsatisfactory WORK, LSTK CONTRACTOR shall immediately at LSTK CONTRACTOR'S expense. take such corrective measures as deemed required.

9.0 CONTROL SYSTEMS

LSTK CONTRACTOR shall initiate and maintain the following control systems

9.1 Backfilling
- Compaction tests.

9.2 Concrete
- Design mix and approval record(s).
- Batch plant inspection record.
- Slump test record.
- Compressive test record.
- Pour release record.
- Grouting release record.
- Placement inspection records.
9.3 **Concrete curing records.**
- Design mix and approval records.
- Batch plan inspection records. Placement inspection records.

9.4 **Asphalt**
- Weld x-ray file.
- Pipe and fitting certificate file.
- Isometric weld control sheet. Hydrostatic test records.

9.5 **Grounding**
Earth resistance test records.

9.6 **Electrical Cable and Instrument cable**
- Insulation resistance test records.
- Continuity test records.

9.7 **Material certification files**

9.8 **Equipment**
- Weld x-ray file.
- Material certificate files.
- Equipment installation records.
- Equipment maintenance record.
- Hydrostatic test records.
- Grouting release records.
- Alignment records.
- Vibration records.

10. **Requirements for Certification of Materials**

10.1 Mill certification of materials will be required based on the material type, the use and the codes and requirements.

10.2 LSTK CONTRACTOR shall provide:

Type A certification of compliance, for all but not limited to the following materials which LSTK CONTRACTOR is responsible to supply:
- Imported backfill materials.
- Ready mix concrete.
- Asphalt paving materials
- Prefab concrete items, including pre-cast manholes, catch basins, pits, sumps and sleepers.
- Paving stones and tiles.
- Inserted and embedded items, other than rebar, wire mesh and anchor bolts.
- Masonry blocks.
- Steel sliding plates.
- Special grouting materials, i.e. non-shrink type.
- Grouting materials, including grounding loop and branch wire which they are LSTK CONTRACTOR'S supply.

Type "B "certificate, for all but not limited to the following materials, which LSTK CONTRACTOR is responsible to supply:
- Materials to be considered structural or structural grade.
- Reinforcing grade.
- Wires mesh reinforcement fabric.
- Anchor bolts.

10.3 **Definition of Type of Certificates**

**Type A (certificate of Compliance):**

This is a certificate of compliance, issued by the manufacturing or processing works and signed by the quality department or persons to carry the responsibility for quality and conformity, stating that the materials supplied correspond with what was agreed in the purchase order.

**Type B (mill Certificate):**

This is a certificate on which the manufacturer's head of quality department confirms that the product supplied corresponds with what has been agreed in the purchase order. Certification shall be on the basis of tests carried out on the material of the product itself, as per purchase order specification. The testing and certification are to be carried out by a testing center which is independent of the production section of the manufacturing works and which has the code-approved facilities. Independence of such testing center should be warranted by LSTK CONTRACTOR.

10.4 **LSTK CONTRACTOR will maintain a systematic filing system of all certificates and reports for all tests and inspections carried out by it under the applicable specifications, standards and codes of practice quoted therein.**

LSTK CONTRACTOR may use its own format for records but this must be submitted to OWNER'S REPRESENTATIVE for his approval prior to use.

LSTK CONTRACTOR can expect to be audited on a continuous basis. Originals of all documents to be sent to OWNER'S REPRESENTATIVE.
ANNEXURE- 7 – 4

SCHEDULE, PROGRESS EVALUATION AND PROGRESS REPORTING

1.0 GENERAL

1.1 WORK shall start and be completed in the field as indicated on the approved project construction schedule.

LSTK CONTRACTOR shall follow the sequence of construction in executing the WORK as shown in the schedule or as modified by OWNER.

The detailed scheduling of WORK will be supplied by the LSTK CONTRACTOR. WORK shall be conducted in such a manner that other construction activities are not affected.

Once detailed schedule, established and approved by OWNER, LSTK CONTRACTOR commits itself to follow the schedule in detail.

2.0 DETAILED & SCHEDULE

2.1 Detailed construction schedule must cover all construction work, from lowest level up to highest level.

2.2 Activities shown by means of a bar chart must include as a minimum the activities listed in 4.

3.0 PROGRESS REPORTING

LSTK CONTRACTOR shall issue a reporting procedure and a representative sample of all progress reports.

Following schedules and reports must be issued by LSTK CONTRACTOR to OWNER:

Construction schedule. (preliminary and detailed)
Monthly status report.
Weekly progress report.
Monthly construction guide schedule.
Daily manpower reports.

All except detailed construction schedule based on approved project construction schedule.

4.0 CONSTRUCTION SCHEDULE
Within Two months after Effective Date, LSTK CONTRACTOR will issue separate graphical "S" curves for the following work activities of total CONTRACT.

Installation of:

- Concrete foundations, pits, manholes, catch basins, trenches and concrete structures.
- Prefabricated concrete items
- Concrete paving and elevated slabs
- Other paving and final surfacing
- Grouting.
- Final road paving.
- Underground piping.
- Underground cable trenches and cables.
- Building erection.
- Structural steel erection.
- Engineering and design of small bore carbon steel piping systems.
- Prefabrication of piping.
- Electrical installation.
- Instrument installation.
- Equipment assembly and erect
- Erection of piping.
- Flushing and cleaning
- Hydro-testing
- Painting
- Insulation.

5.0 INTRODUCTION

The introduction to the monthly status report shall include LSTK CONTRACTOR’S comments on the overall construction schedule with a status update line as attachment, and shall consist of the following items:

- Goals achieved last month.
- Goals for next month.
- Reason for delay, if any. Reason for deviation of original schedule.
- Average manpower by craft, including management and indirect staff.
- LSTK CONTRACTOR’S comments to general situation.

6.0 CONSTRUCTION ACTIVITIES STATUS

This section consists of scheduled versus actual progress curves.

The progress curves are to be commented upon by LSTK CONTRACTOR.

The basis for reporting shall be the construction schedule:
The monthly status shall be reported as a percentage of the total WORK per type of WORK.

7.0 MANPOWER AVAILABILITY / REQUIREMENTS FOR THE MONTH COMING

LSTK CONTRACTOR shall submit its manpower availability requirements for the next month. This section consists also of the scheduled versus the actual manpower curves.

These manpower curves are accompanied by LSTK CONTRACTOR’s comments hereon.

8.0 MAIN CONSTRUCTION EQUIPMENT AVAILABILITY / REQUIREMENTS FOR THE MONTH COMING

LSTK CONTRACTOR shall submit its main construction equipment availability / requirements for the next month. This section consists also of the scheduled versus actual construction equipment requirement curves. These by LSTK CONTRACTOR’S comments hereon.

9.0 WEEKLY PROGRESS REPORT

Progress reporting will be done on a weekly basis by the actually completed work based on details of work such as quantities or piece of equipment as a percentage of the total anticipated work per work activities as defined in item 4.

9.1 Progress will only be reported on the basis of completed activities as per the percentage breakdown of the major steps as follows:

Progress Measurement Parameters

Actual physical progress in the field shall be measured based upon standard percentage of completion of progress stages, that, they are to be prepared by LSTK CONTRACTOR and Approved by OWNER to calculate actual physical progress of the WORK, the exact weight value of each activity from lowest level up to highest level in each category of the WORK shall be specified by LSTK CONTRACTOR and supplied to OWNER.

After OWNER’S Approval this weight value can be used for calculation of actual progress of the WORK

10.0 WEEKLY PROGRESS MEETING

10.1 Weekly Work List

In the weekly progress review meeting LSTK CONTRACTOR shall forecast the WORK it plans to perform during the week by means of a weekly WORK list including its manpower resource allocation as per the activities listed in 4 and 6.

This weekly program shall be in accordance with the construction guide schedules.
10.2 **Work Front**

LSTK CONTRACTOR shall submit monthly and weekly a total recapitulation of the total work front available with estimated manpower requirements, materials and equipment which shall be supplied by LSTK CONTRACTOR.

11.0 **MONTHLY CONSTRUCTION GUIDE SCHEDULE**

Based on approved overall construction schedule, LSTK CONTRACTOR must issue a monthly construction guide schedule covering a two (2) months period, for each individual activity.

Progress updating of construction guide schedules must be weekly and presented in the weekly progress review meeting at site.

The updated issue will show for each individual activity:

- Percent complete.
- Weight factor complete.

12.0 **DAILY MANPOWER REPORTS**

LSTK CONTRACTOR shall be furnished daily manpower report as per agreed format.
ANNEXURE- 7 – 5

EXECUTION PLAN

1.0 BIDDER ORGANISATION

1.1 Company Organisation

Bid shall include a description of the organization, its management structure and organization chart of Bidder's company with particular reference to the means whereby the execution of this project will be related to the overall company organization.

The Bidder shall also furnish the name(s) of their partners, associated/ subsidiary companies & their activities, and whether any such associated/ subsidiary company will be involved in the execution of WORK, and if so, their scope thereof.

1.2 Project Organization

Bidder shall give charts of organization, which he intends to use in the execution of the work. Such charts must show lines of authority and communication of senior personals who will be assigned to this work in Bidder's home - office and other offices where WORK shall be performed (if any) and the lines connecting such Project Organization to the Bidder's internal overall organization including partners (if any). The chart shall be supported by a narrative, which shall explain how the proposed organisation will operate and in particular will provide

The name of the location of the office(s) in which the Basic and Detail Engineering Design Packages of the plant shall be carried out.

If any parts of the Basic and Detail Engineering Design Packages are to be carried out in more than one office, then details of the distribution of the jobs between offices and coordination procedure shall also be presented.

A description of the facilities offered to the OWNER'S resident engineers.

2.0 Estimated project and Engineering man-hours

Bidder shall give an estimate of the engineering man-hours and its break down for all activities

3.0 Methods and procedures

Bidder shall summarise the methods and procedures that BIDDER intends to implement during the performance of the WORK. It shall include the proposed procedures such as Engineering, Procurement, construction strategy, WORK Progress Measurement, Pre-commissioning, Commissioning and Performance Test Run of the PLANT, and Training.

BIDDER shall also furnish proposed procedures for the Project management, communication and method and frequency of reporting the progress of the WORK.

The final form for reports, which will be subject to OWNER's Approval, shall include as a minimum the following :

a) Planning and Scheduling
b) Work Progress

c) Safety and Security

NOTES:

a) Sample reporting forms and other key standard forms shall be included.
b) Bidder shall state the extent to which he will be using computerized drafting, etc.

4.0 Job descriptions and personnel resumes

Bidder shall include job descriptions and personnel resumes of his staff nominated to the key positions, including (where applicable) at least the followings, or Bidder's equivalent:

- Project director
- Process engineering co-ordinator
- Construction manager
- Process engineer
- Project engineering co-ordinator
- Senior pre-commissioning engineer
- Senior commissioning engineer
- Training co-ordinator and instructor.
- Construction Engineering Coordinator
- Construction Quality Control Engineer
- Construction Project Control Engineer
- Welding Specialists
- Heavy Lift Rigging Specialist
- Senior Specialist Engineers
- Senior Planning Engineers
- Materials Coordinators
- Senior Construction Engineers
- Senior Pre-commissioning Engineers
- Warehousing Officer
- Material Planning Engineers

Resumes shall give at least the name, age, nationality, education, professional exception/deviation and previous experience of each assigned personnel. Additionally, one alternative shall be offered for each position. **Bidder shall ensure that personnel to be deployed meet the minimum criteria specified in Annexure-7-6**

Bidder shall confirm that these key personnel will be made available to WORK on the Project as required by the schedule on full time basis.
Bidder shall furnish Summary of its Deployment Schedule Personnel as per **Annexure-7-7**.

Bidder understands that the said proposal represents the minimum deployment and the Bidder acknowledges that the said deployment may have to be augmented with additional number and/or categories, if required, if directed by Engineer-in-Charge in order to complete the work within the completion schedule and quoted lump sum price.

5.0 **Construction equipment and machinery**

The BIDDER shall furnish details of construction equipment & machinery, testing equipment, tools/tackles, etc., which will be made available by the Bidder at the Site. Bidder shall furnish Summary of such details as per **Annexure-7-8, Annexure-7-9**.

Such list shall, in no way limit the CONTRACTOR's responsibility to arrange & provide any additional construction equipment, tools, tackle, etc., which might be required to execute and complete the WORK as per contractual schedule.

BIDDER shall furnish the procedures and his tools for erection of the Heavy Lift Equipments including tall columns):

6.0 **Heavy lifts**

BIDDER shall furnish his proposed, site transportation, lifting, along with preliminary rigging schemes and erection procedure for the heavy lifts. Such plans / schemes shall be furnished along with detailed write -up on heavy cranes proposed to be deployed by CONTRACTOR, duly supported by relevant technical literature.

7.0 **BIDDER experience & exception/deviation to perform the work**

The BIDDER should have experience in the construction of similar Plants. The BIDDER should have successfully executed and completed construction of at least one similar Plant with his own project management and with complete responsibility of construction / erection and pre-commissioning.

The BIDDER shall furnish, as a part of his Tender Documents establishing the BIDDER'S experience and exception/deviation to perform the CONTRACT. Such documentary evidence shall also establish to OWNER's satisfaction that the BIDDER has the necessary financial, technical, project management capabilities and the requisite resources to execute the Work.

Such documentary evidence shall also be furnished for BIDDER'S proposed Subcontractors, if any. The Bidder shall furnish, in a tabular from, a list of jobs of similar type and magnitude executed by them in the past. BIDDER shall also furnish details of their experience in erection of heavy lifts. The Bidder shall furnish documentary evidence, establishing to OWNER satisfaction, that such jobs have been timely and successfully executed by them. The BIDDER shall also furnish the details of their present major commitments.

8.0 **QA/QC Program**

Bidder shall furnish a summary description of their proposed QA/QC program.

Bidder shall furnish any other technical information / details as per the requirements of ITB.

9.0 **Technical assistance**

The extent of the Technical Services and Assistance to be rendered by CONTRACTOR for, commissioning and performance test run, etc., is to be proposed
10.0 Training

Bidder shall furnish the following details regarding the Training of OWNER'S personnel:

a) Bidder's organisation set up for Training program.

b) Training facilities available with the Bidder to train the OWNER'S personnel in:
   - Theory of process, operation, maintenance and manufacturing of products
   - Field (on the job) training in process, operation, maintenance and manufacturing of products, to train the personnel on the job.
   - Test procedure and other matters.

c) The courses and their duration, number of attendees in each course and location where such courses will be held that the Bidder would recommend OWNER to consider.

d) Bidder's experience of training the personnel for units similar to the subject PLANT.

11.0 Estimate of the number of personnel required for the safe and satisfactory operation of the Plant.

For and on behalf of ..............................................
Stamp & Signature  : ..............................................
Name : ..............................................................
Designation : ......................................................
Date : ..............................................................
# ANNEXURE-7-6

## Minimum Qualification & Exp. Of Key Supervisory Construction Personnel

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>CATEGORY</th>
<th>QUALIFICATION &amp; EXPERIENCE</th>
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<tbody>
<tr>
<td>1</td>
<td>RESIDENT CONSTRUCTION MANAGER / RESIDENT ENGINEER / SITE-IN-CHARGE</td>
<td>Degree in Engg. With minimum 20 years relevant experience in construction should successfully constructed &amp; commissioned at least one process unit in hydrocarbon / fertilizer sector.</td>
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<tr>
<td>2</td>
<td>LEAD DISCIPLINE ENGINEER</td>
<td>Degree in relevant Engg. discipline with minimum 15 years experience in Construction or Diploma in relevant Engg. Discipline with minimum 20 years experience in Construction.</td>
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<td>3</td>
<td>LEAD WELDING / NDT ENGINEER</td>
<td>Degree in Mechanical Engg./Metallurgy with minimum 15 years experience in Welding / NDT (Non-Destructive Testing) plus Level-II in RT (Radiographic Testing) or diploma in Mechanical Engg. / Metallurgy with minimum 20 years experience in Welding / NDT plus Level–II in RT.</td>
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<td>4</td>
<td>LEAD QA/QC ENGINEER</td>
<td>Degree in Engg. With 15 years Construction Experience of which 5 years should be as QA Manager.</td>
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<td>5</td>
<td>LEAD PLANNING ENGINEER</td>
<td>Degree in Engg. With 15 years experience in Planning &amp; Scheduling.</td>
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<td>6</td>
<td>LEAD SAFETY OFFICER</td>
<td>Degree / Diploma in Engg. And Diploma in Industrial Safety with min. 10 years relevant experience in Construction Safety.</td>
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<td>7</td>
<td>WAREHOUSE-IN-CHARGE / MATERIALS MANAGER</td>
<td>Graduate in Science or Diploma in Engg. / Materials Management with 15 years experience in Warehousing / Stores Management of similar nature.</td>
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<td>8</td>
<td>DISCIPLINE SURVEYORS</td>
<td>Degree in relevant Engineering Discipline with minimum 3 years experience in Construction or diploma in relevant Engineering Discipline with minimum 6 years experience in Construction.</td>
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<td>9</td>
<td>QUANTITY SURVEYORS</td>
<td>Degree in relevant Engineering Discipline with minimum 3 years experience or diploma in relevant Engineering Discipline with minimum 6 years experience in quantity estimation, field measurement, rate analysis etc. in construction field.</td>
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</table>
For and on behalf of  

Stamp & Signature : 

Name : 

Designation : 

Date : 

For and on behalf of ………………………………
Stamp & Signature : ………………………………
Name : …………………………………
Designation : …………………………………
Date : ………………………………

FORM NO: 02-0000-0021 F2 REV3
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### ANNEXURE-7-7

#### Deployment Schedule of Supervisory Personnel

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<th>SL. NO.</th>
<th>DESCRIPTION</th>
<th>DEPLOYMENT SCHEDULE</th>
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<tr>
<td>4.13</td>
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<td>4.14</td>
<td>WAREHOUSE PERSONNEL</td>
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<td>4.15</td>
<td>MATERIAL MANAGER</td>
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<td>4.16</td>
<td>COMMISSION-ING</td>
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</tr>
<tr>
<td></td>
<td>i) COMMISSION-ING COORDINATOR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii) COMM ENGINEER (SHIFT-IN-CHARGE)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii) CONTROL ROOM COORDINATOR</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Role</td>
<td>Details</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>iv)</td>
<td>FIELD SUPERVISOR</td>
<td></td>
</tr>
<tr>
<td>v)</td>
<td>TECHNICIAN</td>
<td></td>
</tr>
</tbody>
</table>

For and on behalf of ........................................

Stamp & Signature : ........................................

Name : ........................................

Designation : ........................................

Date : ........................................
## Deployment Schedule of Construction Equipment

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>DESCRIPTION</th>
<th>CAPACITY</th>
</tr>
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<tr>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 .. 3 3 4 35 36 37 TOTAL</td>
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<tr>
<td>1</td>
<td>CRANES</td>
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<tr>
<td>1.1</td>
<td>1200 MT</td>
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<tr>
<td>1.3</td>
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<td>1.4</td>
<td>75 MT</td>
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<td>1.5</td>
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<td>1.6</td>
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<td>1.7</td>
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<td>1.8</td>
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<tr>
<td>2</td>
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<td>300 KVA/250KV</td>
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<td>2.3</td>
<td>150 KVA/125KV</td>
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<td>3</td>
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<td>350 CFT</td>
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<td>4</td>
<td>WELDING M/CS</td>
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<td>4.3</td>
<td>WELDING TRANSFORMERS/RECTIFIERS</td>
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<td>4.4</td>
<td>TIG WELDING M/CS</td>
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<td>5</td>
<td>GRIT BLASTING M/CS</td>
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<td>STRESS RELIEVING M/CS</td>
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<td>9</td>
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<td>WATER PUMP</td>
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<td>EXCAVATORS</td>
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<td>13.3</td>
<td>BATCHING PLANT</td>
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All rights reserved
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<td>CONCRETE PUMP CAR</td>
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<td>VIBRATORS</td>
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<td>THEODOLITES</td>
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<td>OTHERS</td>
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<td>INSULATION TESTING EQUIPMENT</td>
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<td>SECONDARY INJECTION TESTING KIT</td>
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<td>METERS, TOOLS &amp; TACKLES ETC</td>
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<tr>
<td>14.4</td>
<td>CALIBRATION EQUIPMENT</td>
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<td>14.5</td>
<td>OTHER TOOLS &amp; TACKLES</td>
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</tr>
<tr>
<td>14.6</td>
<td>MULTI METERS CALIBRATORS ETC</td>
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<td>14.7</td>
<td>INDUCTION PIPE BENDING PLANTS</td>
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<tr>
<td>14.8</td>
<td>METALOGRAPHY</td>
<td></td>
</tr>
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<td>14.9</td>
<td>SPECTROMETERS</td>
<td></td>
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</tbody>
</table>
For and on behalf of:

..............................

Stamp & Signature : ..................................................
Name : ...............................................................
Designation : ..........................................................
Date : .................................................................
## ANNEXURE-7-9
### Details Of Equipment Proposed to be used for Tendered Work

I / We, shall use the following MAJOR equipments owned by the tenderer for the work, if awarded to me/us:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Quantity. (Numbers)</th>
<th>Make</th>
<th>Capacity</th>
<th>Owner</th>
<th>Approximate date when it will be deployed at site</th>
<th>Period of retention at site</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

For and on behalf of ........................................

Stamp & Signature : ........................................

Name : ........................................

Designation : ........................................

Date : ........................................
SECTION: VI – 8.0

PERFORMANCE & GUARANTEE TESTS

PLANTS: STEAM GENERATION PLANT

PROJECT: INTEGRATED COAL BASED FERTILISER COMPLEX AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA)
## CONTENTS

<table>
<thead>
<tr>
<th>Section Number</th>
<th>Description</th>
<th>Sheet Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Performance Guarantees</td>
<td>3</td>
</tr>
<tr>
<td>2.0</td>
<td>Performance Tests</td>
<td>13</td>
</tr>
</tbody>
</table>
1.0 GENERAL

This section describes the guarantee parameter which steam generation package must fulfil and the rejection of the plant by the owner.

Prior to conduct guarantee test, contractor shall demonstrate the operability of individual equipment such as de-aerator, pumps etc. in sustain load test to prove the selected sizes vis-a-vis bid requirement.

Necessary instruments etc. shall be provided by the contractor during performance testing to establish the guarantee parameters.

The contractor shall guarantee the equipment/ complete system for the design, materials, workmanship, size, capacity, performance efficiency and compliance to various technical requirements mentioned in the tender document. The guarantee shall also include sub-ordered /bought out items forming part of the total supplies.

Owner/ consultant inspection OR review of vendor’s design/ drawings/ documents/ deviations shall in no way absolve the vendor OR reduce his responsibility towards this guarantee.

Performance guarantee shall be exclusive if instrument tolerances / uncertainties

2.0 PERFORMANCE GUARANTEES

2.1 The contractor shall submit the detailed performance guarantee test procedure for the performance test for approval of the OWNER/PMC during detail engineering phase, prior to actual conduction of the tests.

LSTK Contractor must fulfil guarantee parameters of Steam Generation Plant as specified in this Clause under the following heads to meet his contractual obligations.

a. Capacity of boilers (All possible combinations of two boilers running) for export steam as well as individual boiler system
b. Internal Power consumption in steam generation plant B.L.
c. Internal steam consumption in steam generation plant B.L.
d. Quality & quantity of Effluent (LSTK to specify): Liquid, Solid & Gaseous
e. Quality and quantity of steam and BFW
f. Noise Level
g. Gaseous Emission
h. Life of the Catalyst (if applicable)
i. Fuel consumption

Failure to meet capacity of the plants, quality of the products, pollution levels, noise levels, gaseous emission shall be breach of contract requiring corrective action by LSTK contractor irrespective of the cost involved.

Bidder shall Guarantee Performance Parameters for the Steam Generation Plant as per followings:

a. Capacity of Steam Generation Plant
b. **Quality of the Product & Effluent**

The quality of steam, BFW & Boiler blow-down from steam generation plant shall be according to the following specifications:

### H.P superheated Steam

<table>
<thead>
<tr>
<th>Description</th>
<th>Normal</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure, kg/cm²g (Min/ Nor/ Max)</td>
<td>107/110/112</td>
<td>130</td>
</tr>
<tr>
<td>Temperature, °C (Min/ Nor/ Max)</td>
<td>515/520/525</td>
<td>545</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica as SiO₂, ppm</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td>pH</td>
<td>9-9.5</td>
</tr>
<tr>
<td>Conductivity, µS/cm (at 25 deg.C)</td>
<td>&lt; 0.2</td>
</tr>
<tr>
<td>Total Iron (Fe) mg/kg</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Na+K mg/kg</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Copper mg/kg</td>
<td>0.003</td>
</tr>
</tbody>
</table>

### Boiler Feed Water (LSTK Contractor)

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Hardness as CaCO₃, mg/l</td>
<td>Nil</td>
</tr>
<tr>
<td>O₂, mg/l</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>Silica as SiO₂, mg/l</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td>pH (at 25 deg. C)</td>
<td>8.5-9.5</td>
</tr>
<tr>
<td>Conductivity, µS/cm (at 25 deg. C before pH adjustment with NH₃)</td>
<td>&lt; 0.3</td>
</tr>
<tr>
<td>Oil, ppm</td>
<td>Nil</td>
</tr>
<tr>
<td>Fe +Cu mg/lt.</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Residual Hydrazine (as N2H₄) Mg/l</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Oxygen consumed in 4 hours, mg/l</td>
<td>Nil</td>
</tr>
</tbody>
</table>

### Effluent

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil &amp; grease PPM</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

### c. Pollution Level
LSTK Contractor shall guarantee the limits of liquid effluents at the Battery Limit, gaseous emission to the atmosphere and noise levels as specified. The determination of the ability of Steam Generation to meet these guarantees will be made during the seven days’ guarantee test or at any other time under similar conditions prior to the Preliminary Acceptance of the Process Plant/Units.

In the event guaranteed pollution level are not fulfilled during the 7 days’ guarantee test it shall be breach of contract, requiring corrective action by LSTK contractor irrespective of the cost involved.

**Gaseous Emission**

**Stack gas Emission Limits**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Source</th>
<th>Suspended Particulate Matter (mg/Nm³)</th>
<th>SOx (mg/Nm³)</th>
<th>NOx (mg/Nm³)</th>
<th>Hg (mg/Nm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Boiler Stack</td>
<td>30</td>
<td>100</td>
<td>100</td>
<td>0.03</td>
</tr>
</tbody>
</table>

The LSTK Contractor may install the FGD unit (if required) to guarantee the gaseous emission as specified above from various points of the ISBL plants.

LSTK Contractor to follow latest norms pertaining to Central Pollution Control Board / State Pollution Control Board norms before submission of the bid.

1. Contractor shall Guarantee and demonstrate that maximum Ammonia slip downstream of SCR reactor shall not exceed 3 ppm at 3-4% oxygen (O2) content in flue gas on dry gas basis from 40 % to 100 % load condition considering the range of coals specified.

2. Contractor shall demonstrate that over entire range of steam Generation operation from 40 % to 100 % and for whole range of specified coal, the total NOx (from thermal as well as from fuel) at the outlet of SCR shall not exceed 100 mg/nm3 at 3-4% oxygen content in the flue gas on dry gas basis.

**d. Noise Level**

LSTK Contractor shall guarantee the noise level within the ISBL Plant premises. Noise nuisance from machinery is normally specified as sound pressure level which for standard design shall not exceed, in work areas, 85dB (a) at 1m distance from each source.

**e. Life of the Catalyst (if applicable)**

The Catalysts in the FGD Unit (if required) & De-NOx unit shall retain their full abilities and performance for the following periods which commence from the date of Preliminary Acceptance of the Plant.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Service</th>
<th>Guaranteed Life (in years)</th>
</tr>
</thead>
</table>
Contractor guarantees that if any catalyst does not meet the guaranteed EOR conditions before the expiry of its guaranteed life as specified in table above, from the date of preliminary acceptance of plant, contractor shall replace as follows:

a) If the catalyst fails to fulfil the guarantee, contractor shall deliver full replacement of catalyst volume free of charge during the entire guaranteed period of 5 years.

Contractor shall pass on to Owner the residual catalyst life as guaranteed by the catalyst manufacturers to Contractor, if any, beyond the guaranteed life of catalyst under contract.

2.2 Works cost (Consumption of Raw material & Utilities) Guarantee:

LSTK bidder shall guarantee the consumption of Raw material and utilities like Coal, Fluxant, De-mineralized water, Instrument Air, and Power required for Steam Generation Plant (2W+1S) in terms of works cost “₹ per MT” of H.P. superheated steam export which will also include superheating of external steam as specified in 2.1a.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Raw Materials/ Utilities</th>
<th>Unit Price ₹ (R)</th>
<th>Consumption per Day(Q)</th>
<th>Cost /Day (R*Q =S) ₹</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Coal, MT</td>
<td>1238</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>Fluxant, MT (If required)</td>
<td>847</td>
<td></td>
<td></td>
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<tr>
<td>3.0</td>
<td>De-mineralised water, M³</td>
<td>53.69</td>
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</tr>
<tr>
<td>4.0</td>
<td>Instrument Air NM³</td>
<td>0.6</td>
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<tr>
<td>5.0</td>
<td>Power KWh</td>
<td>5.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>Cooling Water , M³</td>
<td>35.75</td>
<td></td>
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</tr>
<tr>
<td>7.0</td>
<td>Ammonia (if required), MT</td>
<td>45000</td>
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<td></td>
</tr>
<tr>
<td>8.0</td>
<td>Guaranteed Total Works Cost (“S”/Day) = SUM[S1+...+S7]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.0</td>
<td>Guaranteed Specific Work Cost = SUM [S] / [Total Steam export in a day] “₹ per MT”</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:

i) The guaranteed works cost shall include cost of materials and utilities required, building cooling/heating, lighting, ventilations, air conditioning and consequent costs of such materials which are in the usual operation of the Steam Generation Plant.

ii) Bidder has to provide individual coal consumption for each boiler. However, Coal consumption for which 2 boilers having maximum coal consumption out of three boilers shall be considered.

iii) The above unit prices are indicative and may change at a later date. Revision if any will be intimated to LSTK Contractor before 15 days of price bid opening and the same shall be used for evaluation of the bids.

iv) No instrument/ meter tolerances are allowed.
v) During PGTR, adjustment will be done based on enthalpy difference, if any variation in specified parameters given in works cost table with respect to actual parameters of HP superheated export steam & HP saturated import steam at battery limit.

vi) During PGTR, Required Liquid/ vapour Ammonia shall be arranged by LSTK Contractor. Necessary unloading and Pumping & Handling system shall be provided by LSTK Contractor.

vii) Maximum power available at the B.L of steam generation plant from Client shall be 8 MW during normal operation, accordingly LSTK Contractor shall select the drives of machine keeping in view relevant codes/ guidelines (IBR) requirement.

viii) Custody flow meters of various raw materials & utilities to be provided for permanent measuring arrangements the guaranteed parameters inside their B.L.

In the event works cost is more than 100% but less than 102.5% of the Guaranteed Works Cost then the Contractor will pay owner Mutually Agreed Damages as specified under the Contract. If the Works cost as demonstrated during the performance test is more than 102.5% of the Guaranteed Works Cost then it shall be breach of contract requiring corrective action by LSTK contractor at his risk and cost within reasonable time in consultation with owner.

2.3 Conditions for Guarantees:
Raw materials and utilities in sufficient quantities conforming to the range of specifications supplied to LSTK Contractor by Owner and used as the design basis.

2.4 Consumption of Raw Materials & Utilities:
Consumption of raw materials and utilities shall be measured and calculated as per figures indicated by various calibrated instruments. The guaranteed figures shall be inclusive of all instrument tolerances no further meter tolerance shall be allowed in calculation. All measurement instrumentation shall be part of the system/ plant installed by the LSTK Contractor and no special instrumentation for the purpose of guarantee tests shall be required. Any mobile/portable instrument required temporary for fulfilling the guarantee test shall be arranged by LSTK contractor.

2.5 Basis of Work Cost:
i) Costs mentioned in the clause 2.2 are indicative and may change at a later date. Revision, if any, will be intimated to LSTK Contractor before 15 days of price bid opening and the same shall be used for evaluation of the bids.

ii) The guaranteed works cost shall include cost of materials and utilities required, for building cooling/heating, lighting, ventilations, air conditioning and consequent costs of such materials which are in the usual operation of the plant.

3.0 PERFORMANCE TESTS

3.1 General:
LSTK Contractor shall prove the performance guarantees during tests of the plant as specified in this clause under the following headlines:

- Sustained Load Test
- Guarantee Test
- Measurements during Guarantee Test
- Inconsistent Measurements
- Deviations from Specifications
- Guarantee Test Run Results
- Demonstration Run Results

3.1.1 Sustained Load Test:

After Mechanical Completion, the LSTK Contractor shall commence the Commissioning operations of Plant. After Plant has been commissioned and at least near rated daily capacity has been achieved, LSTK Contractor’s authorised representative shall give notice in writing to Owner that Plant is ready for a sustained load test. On receipt of this notice, but not later than 15 days after the notice, LSTK Contractor shall conduct the sustained load test for consecutive period of total 10 days for all combination of 2 boilers AND/OR Single boiler as per mutual discussion with Owner/PMC. The sustained load test of the plant shall be deemed to have been completed if Plant produces an average of not less than 90% of the daily rated capacity (100% of normal capacity). If, during the sustained load test, there are interruptions due to reasons not attributable to the obligations and responsibilities of LSTK Contractor, periods of such interruptions shall be included and regarded as days of operation at min. 90% of daily rated capacity or actual load prior to interruptions whichever is lower. The cumulative period of such interruptions shall be limited to a maximum of 2 (two) days. Owner shall have the option to reduce the period of sustained load test of 10 days. During the sustained load test, LSTK Contractor shall use their best efforts to ensure that pollution level and noise level are within the limits specified in the Contract. LSTK Contractor shall endeavour to complete the sustained load test within a reasonable period after Mechanical completion, but shall complete the same in any case within 30 days from Mechanical completion. If, during the sustained load test, corrective measures are required and involve procurement of new items of Equipment or modification of items of Equipment which require longer period for delivery than covered by the 60 days period, the period shall be suitably adjusted as agreed with Owner. However, design engineering and placement of orders shall be completed within 45 days from Mechanical completion. On satisfactory completion of the sustained load test, the results achieved shall be tabulated and jointly signed by LSTK Contractor’s and Owner’s representatives within ten days of completing the sustained load test. During the sustained load test, no standby items of Equipment shall be used in parallel for completing the test.
3.1.2 **Notice of Guarantee Test:**
On successful completion of the sustained load test, LSTK Contractor shall give notice in writing for commencing the guarantee test. On receipt of the notice, but not later than 15 days after the notice, LSTK Contractor shall conduct the guarantee test run under the direction of Owner/PMC. During the guarantee test, no stand by items of Equipment shall be used in parallel for proving the guarantee. The range of operating conditions shall be within the design conditions.

3.1.3 **Guarantee Test:**
LSTK Contractor shall give the guarantee test for individual boiler or Combination of any as per discretion by Owner/PMC. The guarantee test shall be carried out for 5 (Five) continuous days without any interruption. In determining the ability of the plant to meet the guarantees all feed rates, product rates and quality, and utility consumption shall be averaged over a period consisting of best continuous 72 hours selected out of the 5 (Five) days test period. The 72 consecutive hours period shall exclude periods during the test when the operating conditions are other than those recommended or approved by LSTK Contractor or periods of non-operation due to failure of Equipment, lack of sufficient feed or utilities, or any other cause beyond the control of LSTK Contractor including the period required to bring Steam Generation plant back to operation at the rate of production achieved prior to the upset. For the purpose of computing the average performance, LSTK Contractor shall select any best continuous 3 days out of the 5 days test period so long as this includes a continuous and uninterrupted run of 72 (Seventy Two) hours and the aggregate total hours of interruptions do not exceed 48 hours.

LSTK Contractor shall be given the max. 3 nos. chance for PGTR. LSTK Contractor’s authorised representative shall give notice in writing to Owner that Plant is ready for a Guarantee Test. On receipt of this notice, but not later than 15 days after the notice, LSTK Contractor shall conduct the guarantee test. On receipt of this notice, but not later than 15 days after the notice, LSTK Contractor shall conduct the guarantee test for consecutive period of total 5 days for all combination of 2 boilers AND/OR Single boiler as per mutual discussion with Owner/PMC. In case of failure (beyond acceptable limits/parameters where Mutually Agreed Damages’ are levied) of 1st Guarantee test, the LSTK Contractor, within 15 days from the beginning of the 2nd guarantee test, shall give a full and detailed statement in writing to OWNER. The statement shall contain the detailed description and corrective measures which LSTK Contractor intends to take and the time required for the same to be completed and a repeat guarantee test to be made. LSTK contractor shall wherever possible shall carry out such corrective measures and repeat the guarantee test within the shortest possible time, but not later than 30 days (or for such time as may be mutually agreed between owner & LSTK contractor) from the beginning of the first
guarantee test unless otherwise agreed with Owner. Further, refer clause no. 34.0 of GCC Part-1 Commercial.
During the Guarantee Test Run, the Production capacity of the Steam generation plants (considering export & internal consumption) & Specific works cost shall be guaranteed as per clause 2.2.
LSTK contractor shall further demonstrate operating capacity of each boiler at 0.4x (LSTK to Specify) Mt/hr for a period of 24 hours to meeting all quality & emission norms.

3.1.4 Measurements during Guarantee Test

For determination of the average performance achieved during the guarantee test, all inputs and outputs shall be measured through appropriate meters specified and installed in plant by LSTK Contractor and jointly calibrated and certified to be correct by LSTK Contractor and Owner. LSTK Contractor shall have all measurements and records certified by Owner beforehand.

3.1.5 Inconsistent Measurements

If any measurement is demonstrably inconsistent with the bulk of the data, or is otherwise suspected to be incorrect, then meter will be re-calibrated. Inconsistency in metering after the calibration if observed then it has to be rectified or in the worst case, meter to be replaced. However in no case, reading should be adjusted.

3.1.6 Deviations from Specifications

In the event that the feed, fuel, utilities, climatic conditions, or any other conditions is not in accordance with conditions specified or referred to in Contract and are prejudicial to LSTK Contractor for establishing the performance guarantee parameters, Owner and LSTK Contractor shall mutually, reasonably, and in good faith negotiate an adjustment to the performance guarantees. Any such adjustments to the performance guarantees shall be made utilising the same methods of calculation as were used in establishing the original performance guarantees to the extent such methods continue to be applicable in accordance with good and sound engineering principles and practice.

3.1.7 Guarantee Test Run Results

Within a reasonable period of time but not later than 10 working days from the completion of the guarantee test Run, Contractor shall determine the results thereof and if in LSTK Contractor's judgement, the performance guarantees have been achieved, submits its calculations and report to Owner/ PMC for Owner’s acceptance. The method of calculation for the Guarantee Test Run shall be mutually agreed by LSTK Contractor, Owner and PMC before starting of Guarantee Test Run. All data will be collected jointly in presence of LSTK contractor, Owner and PMC. Owner/ PMC will review the report, calculations and the supporting data and accept the same in writing, if
the results are in accordance with the provisions of this Section. In case, Owner does not accept the performance guarantee results, Owner shall indicate in writing to LSTK Contractor in what respect the performance guarantees have not been met, within 10 working days of receipt of the report by Owner from the LSTK Contractor. In the event of rejection of Guarantee test Run results by Owner, LSTK Contractor shall take immediate actions to set right as per the provisions of the contract and repeat guarantee test Run to the satisfaction of Owner.
SECTION : VI – 9.0

DRAWINGS AND DOCUMENTS

PLANT : STEAM GENERATION PLANT

PROJECT : INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA
# CONTENTS

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<td>4.0</td>
<td>List of Drawings &amp; Documents</td>
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</tr>
</tbody>
</table>
1.0 DRAWINGS & DOCUMENTS

This chapter details out various drawings and documents to be generated at various stages during the course of execution of the Project by the LSTK Contractor for different project activities. Categorization of the documents/ drawings for review/ information/ records of PMC and the review/ approval requirements of the Owner/ PMC along with routing of the documents/ drawings will be conveyed separately as a philosophy.

The efficient handling of drawings and documents to be prepared by the LSTK Contractor under the contract is the key to the timely completion of the plants. The LSTK Contractor undertakes to ensure that all drawings and documents to be submitted by him to the Owner/ PMC shall be of professional quality and conforming to the contractual requirements. The LSTK Contractor also undertakes to institute a formal drawing control system which will be documented and submitted to the Owner/PMC for review or approval.

Compliance of this chapter on drawings and documents is mandatory and is non-negotiable.

The drawings / documents are to be generated by the LSTK Contractor at various stages of the project covering different activities. The drawings / documents generated will be in the category of Approval/ Review/ Information. The list of drawings and documents required is enclosed; however, the categorisation for the drawings/ documents will be informed separately. However, this will in no way relieve the LSTK Contractor of responsibility to conform to drawings, standards, specification, codes and contractual requirements / obligations.

The LSTK Contractor shall prepare the drawing numbering procedure and submit to Owner/ PMC for approval. Each Drawing submitted by the LSTK Contractor shall be clearly marked with the name of the Owner, PMC with revision number & date. It should contain the minimum following details:

a. Size of Drawing.

b. Discipline of Engineering for which the drawing is issued.

c. Discipline wise segregation of numbering sequence for example:
   100 Series for Process. 200 Series for Mechanical etc.

LSTK Contractor to note that the number corresponds to Steam Generation Plants and shall be prefixed to all related documents/deliverables which shall be indicated to successful bidder.

LSTK Contractor shall submit 4 hard copies & 1 soft copy of drawings/documents for review / approval and for information .

LSTK Contractor shall submit 6 hard copies & 2 soft copies in CDs of final drawings/documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.
Details of the Drawing and Documents submission and tools to be used for generating these documents:

All other documents like presentations etc. and other data shall be in MS Office; the required operating system for Data Exchange shall be at least Windows.

All documents before forwarding to Owner/PMC will have to be vetted in detail by the LSTK Contractor/duly approved engineering sub-contractor appointed by the LSTK Contractor. Document received without vetting will be returned.

The review by the PMC/Owner shall not be construed by the LSTK Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications and drawings.

Each drawing submitted by the LSTK Contractor shall be clearly marked with the name of the Owner, Unit Designation, Specifications, Title, Specification number and the name of the Project with Revision number and date. If standards, catalogue pages are to be submitted, the applicable items shall be indicated therein. All titles, noting, markings and writings on the drawings shall be in English.

All the dimensions should be in metric units. Upon receiving comments on Drawings & Documents by the LSTK Contractor, the subsequent submission should give compliance report, separately on each of the comments, document-wise. Comments given by PMC/Owner to be discussed and finalised within agreed schedule.

The schedule of submission of the Drawings & Documents shall be in accordance with project plans only. The detailed list under different category, document-wise, shall be prepared by the LSTK Contractor for approval of Owner/PMC. This activity is to be completed within one month of Fax of Intent.

Sequence of submission of drawing is essential for proper review of documents and timely completion of the project is to be adhered. In case sequence is not maintained, the documents submitted will not be reviewed by Owner/PMC and responsibility of timely execution of plant shall be to the LSTK Contractor's account.

### 2.0 CATEGORY OF DOCUMENTS

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Action by Owner/PMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Records/ Information</td>
<td>LSTK Contractor can continue to progress with the work. This drawings or documents will be retained with Owner/PMC for information only. Owner/PMC reserves the right to advise the LSTK Contractor of any comments (deviations from the contract) at any time and the LSTK contractor is liable to respond to satisfy that the work being</td>
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<tr>
<td><strong>2</strong></td>
<td><strong>Review</strong></td>
<td></td>
</tr>
</tbody>
</table>

Owner/PMC will review and advise the LSTK Contractor of any Comments on Contractor’s Drawings / documents within specified schedule (i.e. 2 weeks), from date of receipt in PMC office of LSTK Contractor's drawings/documents.

The review period is defined as date of receipt of documents by PMC, to date of issue of comments by PMC.

This review period shall be valid only if submission of drawings is done by LSTK Contractor in accordance with approved drawings / documents schedule as indicated in ITB. In case of any non-conformity to the above by LSTK Contractor due to which the period of review extends beyond 2 weeks by the PMC, schedule delay, if any will have to be absorbed by the Contractor.

The documents falling under Review category will be returned with comments within specified time schedules subject to fulfilling other conditions enumerated. The information category document will be retained for information only but however Owner/PMC reserves the right to comment at any stage of the Project, but not later than two weeks of receipt.

Where clearance of Owner/ PMC is required for ordering of equipment materials, enquiry documents and one technically selected offer is to be submitted for review. The unpriced copies of purchase orders detailing both technical and commercial aspects for all items shall be submitted to PMC/ Owner within 15 days of issue of the same.

Each purchase order forwarded should contain complete technical documents. It is obligatory for the LSTK Contractor to obtain acceptance on all the technical documents and accepted copy only to be forwarded to Owner / PMC. Any inaccuracies /omissions/inconsistencies noticed and brought to the notice of the LSTK Contractor at any stage of the project will be rectified/ replaced by LSTK Contractor without any cost & time implication to the Owner/ PMC.

Detailed manufacturing schedules of fabricated/ manufactured items shall be submitted within one month of ordering, Status report for all the items in detail, will be submitted once in a month.

Documents to Boiler Regulation authorities shall be submitted and getting the documents reviewed by PMC/Owner. To any other agencies, documents shall be submitted under intimation to PMC/Owner.
As built drawings and documents will be generated within one month of completion of activities on respective items of work.

**As Built Drawings:**

LSTK Contractor will furnish reproducible and electronic files of all the drawings under their scope to Owner / PMC, certified as “As-Built Issue” by Third Party Inspection Agency (TPIA) for Vendor Items coming under Third Party Inspection / LSTK Contractor for all other drawings.

Upon completion of identifiable units or components of the fabrication, construction and installation phase of the project the Contractor will complete all the related plans to the "as built' stage including all Vendor drawings and furnish Owner/PMC with the following:

a. One complete set of all original tracings copies.

b. One complete set of reduced size (A3-297x420 mm) copies of all drawings.

c. Two set of CD for all documents/drawings/data

d. All the as built drawings duly certified should be scanned and converted into electronic files made on magnetic/discs/optical long storage.

e. All other project documents such as operating and maintenance manuals, manufacturers' Catalogues etc. shall also be scanned on magnetic/optical discs for safe storage and retrievals by the Owner when needed.

f. 6 complete sets of full size prints of the drawings and 4 sets of reduced size prints.

g. 6 complete bound sets of Manufacturer's specifications including design calculations.

h. 6 complete sets in hard binders of the Manufacturers data book including certified prints and data for all items including test reports. Data Books shall be complete with index as tag numbers associated with Manufacturer's data shown. Equipment data shall include as a minimum requirement the principal and description of operation, drawings and dimensions, spare parts lists and un-priced purchase orders and bill of material.

i. 6 bound copies each of the Spare Parts data books and the Lubricants inventory Schedule.

j. 6 complete sets of field records shall be signed by both the Contractor's and Owner's Representative at the site.

k. Original approvals and related drawings and documents from the statutory authority.

l. Copies of correspondence with the statutory authorities.
3.0 PROCEDURE

The procedure for compilation of final as-built documents / drawings shall be informed later. However the Procedure for routing the final / as built documents/ drawings to PMC / Owner shall be informed during the execution stage.

4.0 LIST OF DRAWINGS & DOCUMENTS

<table>
<thead>
<tr>
<th>S. No</th>
<th>Description</th>
<th>With Bid (Y/N)</th>
<th>For Review/Approval</th>
<th>For Information</th>
<th>Final/Approved/As-built</th>
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</thead>
<tbody>
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</tr>
<tr>
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<td>Y</td>
<td>-</td>
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<td>Process Description</td>
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<td>Process Flow Diagram</td>
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<td>Utility flow diagram</td>
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<td>Y</td>
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<td>6.0</td>
<td>P&amp;I Diagrams</td>
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<tr>
<td>7.0</td>
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<tr>
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<td>Data sheet of all equipment and machinery</td>
<td>N</td>
<td>Y</td>
<td>-</td>
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<tr>
<td>9.0</td>
<td>Process Specifications of catalysts, chemicals, compressors, and reformer</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
<td>Y</td>
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<tr>
<td>10.0</td>
<td>Logic diagrams</td>
<td>N</td>
<td>Y</td>
<td>-</td>
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<td>11.0</td>
<td>Safety valve Specifications</td>
<td>N</td>
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<td>Instrumentation Control philosophy</td>
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<td>13.0</td>
<td>HAZOP Study and Compliance report</td>
<td>N</td>
<td>Y</td>
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<td>Flare Load Summary</td>
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<td>Plot Plan (Preliminary)</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>16.0</td>
<td>Operating Manuals and maintenance manuals</td>
<td>N</td>
<td>Y</td>
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<td>Analytical Manual</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>B.</td>
<td>STATIC EQUIPMENTS/BOILER</td>
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<tr>
<td>1.0</td>
<td>Filled in Data Sheets of pressure equipment along with outline sketches showing thickness of main parts, weight (erection &amp; operating) and anchorage details</td>
<td>N</td>
<td>Y</td>
<td>-</td>
<td>Y</td>
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<tr>
<td>2.0</td>
<td>General arrangement for package items showing plan, elevation &amp; end view</td>
<td>N</td>
<td>Y</td>
<td>-</td>
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<tr>
<td>3.0</td>
<td>Recommended spares for commissioning &amp; 2 years operation</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
<td>-</td>
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<tr>
<td>4.0</td>
<td>Details of internals including demister, i.e. make and model No., free volume, wire dia, surface area, and density of material and separation efficiency.</td>
<td>N</td>
<td>Y</td>
<td>-</td>
<td>Y</td>
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<tr>
<td>5.0</td>
<td>Civil load data including details of foundation/anchor bolts</td>
<td>N</td>
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<td>Y</td>
<td>Y</td>
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<td>6.0</td>
<td>Drawing list</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>7.0 A</td>
<td>GA Drawing of equipment along with design calculation, thermal design, general notes &amp; ITP.</td>
<td>N</td>
<td>Y</td>
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<td>Y</td>
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<tr>
<td>7.0 B</td>
<td>Mechanical &amp; Structural Design calculations for Internals including fabrication drgs. of Internals complying with the specifications and codes</td>
<td>N</td>
<td>-</td>
<td>Y</td>
<td>Y</td>
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<td>7.0 C</td>
<td>Thermal calculations of equipment and hydraulic calculations of internals</td>
<td>N</td>
<td>Y</td>
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<td>8.0</td>
<td>Skin temperature vs. Metal tube length curve for super heaters, economizer &amp; Air Preheater etc.</td>
<td>N</td>
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<td>-</td>
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<tr>
<td>9.0</td>
<td>Specifications for Acid/Alkali cleaning</td>
<td>N</td>
<td>-</td>
<td>-</td>
<td>Y</td>
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<tr>
<td>10.0</td>
<td>Welding procedure and performance records approved by inspecting authority (**)</td>
<td>N</td>
<td>Y</td>
<td>-</td>
<td>Y</td>
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<tr>
<td>No.</td>
<td>Description</td>
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<td>Y</td>
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<td>11.0</td>
<td>Operating/Maintenance manual for mechanical items wherever required</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>12.0</td>
<td>Transportation drawing showing overall dimension, C.G. weight and handling instructions duly approved by appropriate authority</td>
<td>N</td>
<td>Y</td>
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<td>13.0</td>
<td>Procedure for hydraulic test and heat treatment</td>
<td>N</td>
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<td>Procedure for tube to tubesheet joint</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>15.0</td>
<td>Procedure for repair of damaged tubes</td>
<td>N</td>
<td>Y</td>
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<td>16.0</td>
<td>Procedure for site jobs like assembly, heat treatment, testing ,application of painting &amp; insulation etc.</td>
<td>N</td>
<td>Y</td>
<td>-</td>
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<tr>
<td>17.0</td>
<td>Records of NDT tests e.g. Radiography, Ultrasonic Testing(UT), Magnetic Particle / Penetrant Testing (MP/PT), hardness etc.</td>
<td>N</td>
<td>Y</td>
<td>-</td>
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<tr>
<td>18.0</td>
<td>Records of vacuum box test plumbness, roundness, peaking, banding etc.</td>
<td>N</td>
<td>Y</td>
<td>-</td>
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<td>19.0</td>
<td>Materials test certificates duly stamped by inspecting authority</td>
<td>N</td>
<td>Y</td>
<td>-</td>
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<td>PWHT Charts</td>
<td>N</td>
<td>Y</td>
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<td>21.0</td>
<td>Mock-up test for Tube To Tube sheet joint</td>
<td>N</td>
<td>Y</td>
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<td>22.0</td>
<td>Test on production test coupons</td>
<td>N</td>
<td>Y</td>
<td>-</td>
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<tr>
<td>23.0</td>
<td>Corrosion test reports including C, Cr, Ni, Mo and ferrite contents report of raw materials, weldments, HAZ etc.</td>
<td>N</td>
<td>Y</td>
<td>-</td>
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<td>Hydraulic/pneumatic/Hydro-Pneumatic test reports</td>
<td>N</td>
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<td>Strain gauge measurement</td>
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<td>26.0</td>
<td>Foundation settlement check record</td>
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<td>27.0</td>
<td>Calibration report</td>
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<td>28.0</td>
<td>All final As-built shop drgs. &amp; design calculations duly certified by Third Party inspecting</td>
<td>N</td>
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<tr>
<td>29.0</td>
<td>Records/ drawings, charts duly approved, signed and stamped by Statutory Authorities (**)</td>
<td>N</td>
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<td>30.0</td>
<td>All Radiography films or summary report wherever Applicable (**)</td>
<td>N</td>
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<td>Mechanical Guarantee Certificate (**)</td>
<td>N</td>
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<td>32.0</td>
<td>Inspector's final certificate (**)</td>
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<td>-</td>
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<td>33.0</td>
<td>Material and Purchase Requisitions for Static Equipments &amp; Boiler</td>
<td>N</td>
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<th>Pumps</th>
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<td>List of drawings / documents including drawing number, revision number, description and approval status</td>
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<td>2.0</td>
<td>Detailed manufacturing programme (Time bar chart)</td>
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<tr>
<td>3.0</td>
<td>Certified dimensional outline drawing</td>
</tr>
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<td>4.0</td>
<td>Cross sectional drawing and bill of material</td>
</tr>
<tr>
<td>5.0</td>
<td>Shaft seal drawing and bill of material</td>
</tr>
<tr>
<td>6.0</td>
<td>Shaft coupling assembly drawing and bill of materials including allowable misalignment clearances, shaft bores &amp; key ways dimensions with tolerances and the style of coupling guard</td>
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<tr>
<td>7.0</td>
<td>Primary &amp; auxiliary sealing schematic and bill of materials including seal fluid, fluid flows, pressure pipe and valve sizes, instrumentation, orifice sizes, and piping arrangement drawings</td>
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<tr>
<td></td>
<td>Description</td>
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<td>8.0</td>
<td>Cooling or heating schematic and bill of materials including cooling &amp; heating media, fluid</td>
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<td></td>
<td>flows, pressure, pipe and valve sizes, instrumentation, orifice sizes and piping arrangement</td>
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<td>drawings</td>
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<td>9.0</td>
<td>Lube oil schematic and bill of materials</td>
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<td>10.0</td>
<td>Lube oil system arrangement drawing including sizes, rating and location of all customer</td>
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<td>connections</td>
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<td>11.0</td>
<td>Lube oil component drawings data</td>
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<td>12.0</td>
<td>Electrical and instrumentation schematics, wiring diagrams and bill of materials</td>
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<tr>
<td>13.0</td>
<td>Electrical and instrumentation arrangement drawing and list of components</td>
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<td>14.0</td>
<td>Performance curves</td>
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<td>15.0</td>
<td>Pump specification sheet with complete details in Performa enclosed with enquiry / order</td>
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<tr>
<td>16.0</td>
<td>Certified foundation assembly drawing of pump with driver &amp; all accessories mounted on base plate</td>
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<tr>
<td></td>
<td>with load diagram for foundation design (in case of motor being procured by purchaser, motor</td>
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<td></td>
<td>frame details will be supplied to vendor within 4 weeks.)</td>
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<td>17.0</td>
<td>Engineering flow diagram showing:</td>
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<td></td>
<td>- Lubrication &amp; sealing lines</td>
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<td></td>
<td>- Flushing / washing lines</td>
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<tr>
<td></td>
<td>- Cooling / steam lines</td>
</tr>
<tr>
<td>18.0</td>
<td>Reference list for pumps supplied in past for similar duty conditions. Reference list shall</td>
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<tr>
<td></td>
<td>contain complete address of user, user's purchase order number, brief specifications and date</td>
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<td>of commissioning</td>
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<td>19.0</td>
<td>Lube oil schedule</td>
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<td>Description</td>
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<tr>
<td>20.0</td>
<td>Automatic recirculation valve assembly drawing, sectional drawing with bill of material</td>
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<td>21.0</td>
<td>Quality Assurance Plan.</td>
</tr>
<tr>
<td>22.0</td>
<td>Material test certificates and Inspection &amp; performance test report along with dispatch clearance certificates from inspector</td>
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<tr>
<td>23.0</td>
<td>Instruction manuals describing installation, operation and maintenance procedures</td>
</tr>
<tr>
<td>24.0</td>
<td>Spare parts recommendations and price list</td>
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<tr>
<td>25.0</td>
<td>Parts catalogue complete with reference drawing nos. and sketches etc.</td>
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**D. COMPRESSORS**

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<tr>
<th></th>
<th>Description</th>
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<td>3.0</td>
<td>Specification sheet complete filled in PDIL proforma enclosed with enquiry/order.</td>
<td>N</td>
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<td>4.0</td>
<td>Equipment layout with main overall dimensions including those required for foundations and piping design for compressor and auxiliaries. (This layout shall include the driven equipment and its auxiliaries).</td>
<td>Y</td>
<td>Y</td>
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<tr>
<td>5.0</td>
<td>Performance curves for Centrifugal compressor :</td>
<td>N</td>
<td>Y</td>
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</table>

i) For turbine driven compressor, Discharge pressure, Brake horse power, Polytropic head and Efficiency Vs Inlet capacity (from surge point to 115 % of rated capacity) of the compressor at specified inlet pressure, temp. and mol. wt. of the gas and at 80, 90, 100 and 105 % speed for each stage and
<table>
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<tr>
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<td>4.0</td>
<td>for overall compressor</td>
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<td></td>
<td>ii) For constant speed motor driven compressors Discharge pressure, Brake horse power, Polytropic head and Efficiency Vs Inlet capacity (from surge point to 115% of rated capacity) of the compressor at specified inlet pressure, temp. and mol. wt of the gas for each stage and for overall compressor</td>
<td>N</td>
<td>Y</td>
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<td></td>
<td>iii) Torque Vs Speed curve for the compressors.</td>
<td>N</td>
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<td>6.0</td>
<td>Performance Curve</td>
<td>N</td>
<td>Y</td>
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<td></td>
<td>i) Calculation of the lateral critical speeds of the compressors.</td>
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<td>iii) Thrust loading curves for each casing / barrel for various operating conditions.</td>
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<td>iv) Response curve of deflection Vs RPM for varying amount of imbalance.</td>
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<td>v) Torsional critical response curve</td>
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<td>7.0</td>
<td>Overall dimensional drawing with all main dimensions, size and location of piping connections for compressors and its auxiliaries.</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>8.0</td>
<td>Cross sectional drgs. Of the compressor showing details of construction including sealing details, bearing etc. With part no., description and material of construction.</td>
<td>N</td>
<td>Y</td>
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<td>9.0</td>
<td>Coupling drawings</td>
<td>N</td>
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<td>Y</td>
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<td>Seal assembly drawings &amp; Bill of material</td>
<td>N</td>
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<td>Lube oil Pumps</td>
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<td>a) Specification sheet</td>
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<td></td>
<td>b) Performance curve</td>
<td>N</td>
<td>Y</td>
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<td>c) Cross Sectional drawing</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
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<td>13.0</td>
<td>Certified foundation scope drawing of the compressor with driver and all accessories resting on the foundation and control panel. In the event of motor not in the scope of supply of vendor the motor frame dimensions shall be supplied by the purchaser later). Direction and magnitude of all unbalanced forces, couples and centre of gravity along with direction of rotation shall also be mentioned.</td>
<td>N</td>
<td>Y</td>
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<td>Y</td>
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<tr>
<td>14.0</td>
<td>a) Engineering flow diagram indicating all instruments, valves, etc. marked with battery limit of supply of:</td>
<td>Y</td>
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<td></td>
<td>- Process Gas lines</td>
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<td>- Cooling Water lines</td>
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<td>- Lubricating Oil lines</td>
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<td>- Condensate drain and vent lines</td>
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<td>The above drawings shall identify all components by size, pressure rating and material</td>
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<td>b) Material balance for gas, lube &amp; seal oil.</td>
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<td>15.0</td>
<td>Piping layout plan and elevation drawings for gas, cooling water and utility lines, lube and seal oil lines etc.</td>
<td>N</td>
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<td>Driver : Selection details</td>
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<td>a) Speed - torque diagram</td>
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<td>b) GD2 of the rotating masses of the compressor referred to the motor speed</td>
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<td>17.0</td>
<td>a) Piping isometrics for gas pipes DN&gt;20, piping manifold and all oil lines.</td>
<td>N</td>
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<td></td>
<td>b) Flexibility analysis for gas lines.</td>
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<td>Piping support location drgs.</td>
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<td></td>
<td>With forces, moments and movements for gas pipes and with weights for all lines.</td>
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<td>19.0</td>
<td>Certified allowable forces, moments, movements, stresses for compressor nozzles.</td>
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<td>Bill of Material for Piping and supports.</td>
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<td>Bill of Material for insulation for Piping.</td>
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<td>22.0</td>
<td>Bill of quantity for Painting for piping, equipments and auxiliaries.</td>
<td>N</td>
<td>Y</td>
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<td>23.0</td>
<td>Thermal calculation for heat exchangers, Mechanical calculation and fabrication drawings for heat exchangers and Pressure vessels.</td>
<td>N</td>
<td>Y</td>
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<td>Inspection and Test Procedure.</td>
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<td>Quality Assurance Plan.</td>
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<td>26.0</td>
<td>Inspection and test reports, material test certificates, radiographic reports duly approved by specified inspecting authority, certificates for compressors, heat exchangers, pressure vessels, pipings, valves, instruments and other auxiliaries.</td>
<td>N</td>
<td>-</td>
<td>-</td>
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<td>Lubrication schedule</td>
<td>N</td>
<td>-</td>
<td>-</td>
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<td>28.0</td>
<td>Instruction manual for erection, installation, operation and maintenance of compressor and its accessories (important clearances to be maintained should be clearly specified.).</td>
<td>N</td>
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<td>29.0</td>
<td>Recommended list of spares for two years trouble free operation</td>
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<td>List of special tools</td>
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### Installation list of similar machines shall also include the following:

- **Client, location and year of installation**
- **Drive**
- **Model No. and type of compressor**
- **Duty condition of the compressor**
- **Speed and KW rating**

### E. TURBINE

#### 1.0 List of drawings / documents including drawing number, revision number, description and approval status

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#### 2.0 Detailed manufacturing programme (Time bar chart)

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#### 3.0 Specification sheet with complete details in proforma enclosed with enquiry/order

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#### 4.0 Equipment layout with main overall dimensions including those required for foundations and piping design for Turbine and auxiliaries.

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<td>Performance curves for steam turbine:</td>
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<td></td>
<td>a) steam consumption versus KW (for various extraction rate in case of extraction turbine)</td>
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<td></td>
<td>b) overall efficiency vs. load curve</td>
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<td>c) steam consumption correction curves</td>
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<td>d) curve showing variation of exhaust temperature with inlet flow (i.e. under various loads):</td>
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<tr>
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<td>- for change in live steam pressure</td>
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<td>- for change in live steam temperature</td>
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<td></td>
<td>- for change in speed from governor set point speed to max. continuous speed</td>
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<td>- for change in cooling water inlet temperature from 25°C to 35°C</td>
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<td>6.0</td>
<td>Thrust loading curves of each casing / barrel for various operating conditions</td>
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<td>7.0</td>
<td>Overall dimensional drawing with all main dimensions, size and location of piping connections for turbine and its auxiliaries.</td>
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<td>8.0</td>
<td>Cross sectional drawings of the turbine showing details of construction including governor, inlet trip and control valves sealing details, bearing details etc. With part no., description and material of construction.</td>
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<td>Description of governing system</td>
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<td>Blading plan for turbine</td>
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<td>11.0</td>
<td>Coupling drawings</td>
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</table>
|12.0| a) Engineering Flow diagram indicating all the Instruments with limit of supply of steam and condensate lines, lube and control oil lines, Flushing and washing line and cooling water lines.  
b) Material balance for steam condensate, lube & control oil.                                                                                     | N | Y | - | Y |
|13.0| Certified civil scope drawings for foundation of steam turbine and all auxiliaries.                                                                                                                            | N | Y | - | Y |
|14.0| Piping layout plan, elevation and support drawings for steam and condensate lines, lube and control oil lines, gland sealing steam lines, flushing and washing lines.                                             | N | Y | - | Y |
|15.0| a) Piping isometrics for steam pipes for DN>20, piping manifold and all oil lines  
b) Flexibility analysis for steam lines                                                                                                              | N | Y | - | Y |
<p>|16.0| Piping support location drgs. With forces, moments and movements for steam and condensate pipes and with weights for all lines                                                                                  | N | Y | - | Y |
|17.0| Certified allowable forces, moments, movements, stresses for turbine nozzles.                                                                                                                                   | N | - | Y | Y |
|18.0| Calculation of the lateral critical speeds of the turbines, Campbell diagram and Goodman diagram.                                                                                                              | N | - | Y | Y |
|19.0| Bill of materials for piping and supports.                                                                                                                                                                     | N | Y | - | Y |
|20.0| Bill of materials for insulation for piping.                                                                                                                                                                    | N | Y | - | Y |
|21.0| Bill of quantity for painting for piping, equipments and auxiliaries.                                                                                                                                         | N | Y | - | Y |</p>
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<td>Thermal calculation for heat exchangers, Mechanical calculation and fabrication drawings for heat exchangers and pressure vessels.</td>
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<td>Cross sectional drawings of the Barring gear.</td>
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<td>Quality Assurance Plan.</td>
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<td>28.0</td>
<td>Inspection and test reports, material test certificates, radiographic reports duly approved by specified inspecting authority.</td>
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<td>Parts catalogue complete with reference drawing nos. and sketches etc.</td>
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**F. FANS & BLOWERS**

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<td>Characteristic Curves - Performance curves, showing discharge pressure, capacity, and brake horse power at the inlet specified conditions (Pressure, capacity, temperature, molecular weight).</td>
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<td>a) Type</td>
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<td>b) HP absorbed at duty point</td>
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<td>c) RPM</td>
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<td>d) Recommended HP</td>
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<td></td>
<td>e) Max. starting torque as % NRT</td>
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<td>f) GD₂ figure for rotating mass of the Fan / Blower</td>
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<td>g) Speed vs. Torque for the Fan / Blower</td>
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<td>General Arrangement Drawing with all main dimensions, size and location of connections for ducting with all horizontal &amp; vertical clearance necessary for installation and disassembly.</td>
<td>N Y</td>
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<td>Cross sectional drawing of fan with parts list</td>
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<td>Instruction manual for erection, installation operation and maintenance of fan and its accessories (Important clearances to be maintained should be clearly specified).</td>
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<td>Reference list indicating duty condition, location, year of installation, name of client etc.</td>
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<td>GA drawing with all details &amp; dims. Including fan, drive, motor</td>
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<td>Description of capacity control with details</td>
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<td>Information to be supplied by manufacturer / Vendor</td>
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<td>General arrangement Drg. showing various details &amp; all principal dimensions of the assembled unit, horizontals and vertical clearances and approaches.</td>
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<td>List of spare parts with individual part Nos. and prices.</td>
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<td>Descriptive literature / catalogue</td>
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<td>6</td>
<td>Detailed manufacturing programme Time-Bar Chart</td>
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<td>7</td>
<td>Individual structural drgs. For main girders and End-carriages.</td>
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<td>Mechanical calculations (Brakes, Gear boxes, gears, pinions coupling, Bearing, Rope-drum, Wire-rope etc.</td>
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<tr>
<td>No.</td>
<td>Description</td>
<td>Available</td>
<td>Required</td>
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<td>9</td>
<td>Civil load data drawing, Cross-sectional detailed drawings of sub-assemblies part nos., materials of construction and heat treatment details wherever applicable</td>
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<td>a) General Assembly Drg. Showing the complete mechanical details</td>
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<td>Crane rail &amp; end stops fixing arrangement</td>
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<td>Material test certificates (including the originals) of load bearing parts e.g.</td>
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<td>Crane rail &amp; end stops fixing arrangement</td>
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<td>Test certificates of motors (including the originals)</td>
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<td>16</td>
<td>Certificates of No load, load, over load deflection Test duly witnessed by the Inspector</td>
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<td>17</td>
<td>Operation &amp; Maintenance Manual (including the lubrication schedule also.)</td>
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<td>18</td>
<td>Drg. Showing the supporting arrangement of flexible cable with main bridge and trolley</td>
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I HVAC System

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<td>General Assembly drawings - with main overall dimensions including those required for accessories and auxiliaries and all horizontal &amp; vertical clearances for dismantling, direction of rotation etc.</td>
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<td>Description</td>
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<td>5</td>
<td>Description of Lubrication and sealing system (if any).</td>
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<td>6</td>
<td>Manufacturing schedule.</td>
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<td>7</td>
<td>Cross-Sectional drawing of AC Plant and auxiliaries alongwith Bill of Materials.</td>
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<td>8</td>
<td>Parts catalogue complete with reference drawing numbers &amp; sketches etc.</td>
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<td>9</td>
<td>Instruction manuals for erection, installation, operation and maintenance of AC Plant and accessories.</td>
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<td>Material test certificates and Inspection &amp; performance test report alongwith despatch clearance certificates from inspector.</td>
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<td>Reference list for similar types of AC Plant supplied in past for similar duty conditions. Reference list shall contain complete address of user, user’s purchase order number, brief specifications and date of commissioning along with operating conditions.</td>
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<td>Lube oil schedule, if any.</td>
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<td>Drivers specification and Drg.</td>
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### J. CIVIL & STRUCTURALS

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<td>Structural Sectional drawings, platforms, Ladders, Walkways &amp; Staircases</td>
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### K. PIPING

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**L. MATERIAL HANDLING**

| 1. | Overall plot plan | Y | Y | - | Y |
| 2. | Scheme / Layout drg. Of Coal and Ash Handling system | Y | Y | - | Y |
| 3. | PFD of Coal and Ash Handling System | Y | Y | - | Y |
| 4. | GA Drawings of all the Coal and Ash handling System equipments along with detail specification of each equipment. | N | Y | - | Y |
| 5. | Mechanical G.A drg. of all buildings (e.g. Silo, Transfer Tower building etc.) showing Coal and Ash handling equipments | N | Y | - | Y |
| 6. | Specification/ Data Sheet of all the coal and Ash handling equipments | Y | Y | - | Y |
| 7. | Coal and Ash Handling System Design Calculation | N | Y | - | Y |
| 8. | Foundation Drawings for each Equipment | N | N | Y | N |
| 9. | Fabrication Drawings of All Equipment | N | N | Y | N |
| 10. | Lubrication Schedule | N | N | Y | N |
| 11. | Complete Spare Part List for 2 years operation | Y | Y | - | Y |
| 12. | Operation and maintenance manuals. | N | N | Y | N |

**M. ELECTRICAL**

<p>| 1.0 | Load List indicating rated and absorbed power of loads and duty type (Continuous / Standby / Intermittent) at different voltages including emergency loads. | Y | - | Y | Y |
| 2.0 | Load Data indicating normal, peak, starting and construction power requirement at various voltage levels. | Y | - | Y | Y |
| 3.0 | Single line distribution diagram (power, lighting, DC supply and UPS supply) including protection | Y | Y | - | Y |</p>
<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Y</th>
<th>N</th>
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<tbody>
<tr>
<td>4.0</td>
<td>Filled in Specification Sheets and Technical Particulars, provided in the NIT</td>
<td>Y</td>
<td>N</td>
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<tr>
<td>5.0</td>
<td>Specification Sheets and Technical Particulars of Electrical Equipment</td>
<td>N</td>
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<tr>
<td>6.0</td>
<td>General arrangement and foundation drawings of all equipment.</td>
<td>N</td>
<td>-</td>
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<td>7.0</td>
<td>Equipment layout in Sub Station, MCC room, and plant area showing location of all electrical equipment.</td>
<td>N</td>
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<td>8.0</td>
<td>Cable schedule.</td>
<td>N</td>
<td>Y</td>
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<td>9.0</td>
<td>Cable rack / trench / pipe layout.</td>
<td>N</td>
<td>Y</td>
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<td>10.0</td>
<td>Power Layout.</td>
<td>N</td>
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<td>Schematic diagram for all control panel &amp; switch boards.</td>
<td>N</td>
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<td>12.0</td>
<td>Feeder Details of all switch boards</td>
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<td>Y</td>
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<tr>
<td>13.0</td>
<td>Interconnection &amp; Terminal connection diagram</td>
<td>N</td>
<td>-</td>
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<tr>
<td>14.0</td>
<td>List of controls, interlocks, indication &amp; metering at various locations for all drives.</td>
<td>N</td>
<td>-</td>
<td>Y</td>
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<tr>
<td>15.0</td>
<td>Characteristic curves for motor/relays etc.</td>
<td>N</td>
<td>-</td>
<td>Y</td>
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<tr>
<td>16.0</td>
<td>Sizing Calculations for Electrical System and Equipment.</td>
<td>N</td>
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<tr>
<td>17.0</td>
<td>Electrical System Study Report (both hard as well as editable working files with complete library / back-up)</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>18.0</td>
<td>Design calculations (for system design and equipment sizing, earthing, lighting, cables, bus ducts etc.)</td>
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<td>19.0</td>
<td>Earthing and lightning protection layout</td>
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<td>20.0</td>
<td>Lighting layout and Distribution diagram</td>
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<td>Y</td>
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<td>21.0</td>
<td>Drawings and documents asked for each equipment as per respective Technical Specifications</td>
<td>N</td>
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<td>Control &amp; operation write up/Block logic diagrams.</td>
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<td>Catalogues for all bought out items</td>
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<tr>
<td>24.0</td>
<td>Bill of Materials covering all electrical equipment and</td>
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<td>25.0</td>
<td>Installation operation and maintenance (Manual)</td>
<td>N</td>
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<td>26.0</td>
<td>Relay Co-ordination and settings</td>
<td>N</td>
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<td>27.0</td>
<td>Spare Parts list</td>
<td>Y</td>
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<td>28.0</td>
<td>Test Certificates</td>
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<td>Guarantee Certificates</td>
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<td>Quality Assurance Plan &amp; Formats</td>
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<td>Hazardous area Classification Drawing</td>
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<td>Erection Drawings &amp; Details</td>
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<td>N</td>
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<td>Any other drawings &amp; data as required for satisfactory installation, operation &amp; maintenance.</td>
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**N. INSTRUMENTATION**

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<td>4</td>
<td>Utility requirements</td>
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<td>Level sketches</td>
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<td>Instrument duct / tray layout</td>
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<td>Instrument cable schedule</td>
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<td>Instrument location plans</td>
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<td>Start up &amp; commissioning</td>
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<td>25</td>
<td>Inspection &amp; test procedures</td>
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<td>26</td>
<td>Complete catalogues with part list for all vendor supplied instruments, control etc.</td>
<td>N</td>
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<tr>
<td>27</td>
<td>Installation, operation &amp; maintenance manuals</td>
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<td>AsBuiltDrawings</td>
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**O. GENERAL**

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<td>1.0</td>
<td>Master Time Schedule/Network (PERT Network/ Bar chart) showing all the activities</td>
<td>Y</td>
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<td>2.0</td>
<td>Reference list for similar packages supplied and executed by the bidder with details.</td>
<td>Y</td>
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<td>3.0</td>
<td>Detailed Painting &amp; Insulation Specifications</td>
<td>N</td>
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<td>4.0</td>
<td>Complete Spare Part List for the whole package</td>
<td>Y</td>
<td>Y</td>
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<td>5.0</td>
<td>List of all construction equipments, tool-tackles &amp; manpower resources proposed to be used.</td>
<td>Y</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>6.0</td>
<td>Description and Catalogues of Auxiliary items</td>
<td>Y</td>
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</table>
SECTION : VI – 10.0

SPARE PARTS

PLANT : STEAM GENERATION PLANT

PROJECT : INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA
## CONTENTS

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<td>Mandatory spare parts</td>
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<td>2.1</td>
<td>Process Items</td>
<td>3</td>
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<tr>
<td>2.2</td>
<td>Centrifugal Compressor</td>
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</tr>
<tr>
<td>2.3</td>
<td>Screw Compressor</td>
<td>4</td>
</tr>
<tr>
<td>2.4</td>
<td>Centrifugal Fan</td>
<td>5</td>
</tr>
<tr>
<td>2.6</td>
<td>Steam Turbine</td>
<td>5</td>
</tr>
<tr>
<td>2.7</td>
<td>Centrifugal Pump</td>
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<tr>
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<td>Reciprocating Pump</td>
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<td>2.9</td>
<td>Metering Pump</td>
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<td>Agitators</td>
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<td>2.11</td>
<td>EOT Cranes</td>
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<td>2.12</td>
<td>Static Equipments</td>
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<td>Electrical Items</td>
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<td>2.15</td>
<td>Instrumentation Items</td>
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<td>Material Handling items</td>
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<td>2.17</td>
<td>Fire Fighting</td>
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<td>Vendor recommended spare parts</td>
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<td>Maintenance Tools and Tackles</td>
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## LIST OF ATTACHMENTS

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FORM NO: 02-0000-0021F3 REV5
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1.0 SPARE PARTS FOR COMMISSIONING

1.1 LSTK Contractor shall supply free of cost all spares and consumables covering pre-commissioning, commissioning, testing, PGTR and till handing over of the Steam Generation Plant.

1.2 Supply of Mandatory Spares/Insurance spares for Electrical/Mechanical/Instrumentations and other plant machinery shall be under LSTK Scope.

1.3 Supply of spares and consumables post handing over of the plant shall be under Owner’s scope.

1.4 LSTK Contractor shall submit/provide recommended 2 years O&M spares (other than Mandatory spares) list with budgetary offers valid for 2 years from the date of submission of offer for TFL/Owners consideration.

2.0 MANDATORY / INSURANCE SPARE PARTS

LSTK Contractor shall supply mandatory spare parts of the plant as detailed below.

a) Process Items
b) Centrifugal / Axial / Rotary Compressor
c) Reciprocating Compressor
d) Screw Compressor
e) Centrifugal Fan
f) Steam Turbine
g) Centrifugal Pump
h) Reciprocating Pump
i) Metering Pump
j) Agitator
k) EOT cranes
l) Static Equipments
m) Piping items
n) Electrical items
o) Instrument items
p) Material Handling items
q) Fire & Safety.

2.1 Process Items

<table>
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<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>Catalysts, Adsorbents (as required)</td>
<td>10% of full charge</td>
</tr>
</tbody>
</table>

Note: Catalyst life shall be as per the guaranteed performance criteria in Technical ITB Section 8.0

2.2 Centrifugal Compressor (for air / HVAC services, if applicable)

The mandatory spares to be supplied for each working train/unit shall be as under. No spares considered for standby unit.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>COMPRESSOR</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Completely assembled dynamically balanced spare rotor including clearance check and mechanical run test</td>
<td>1 set</td>
</tr>
<tr>
<td>1.2</td>
<td>Complete spare coupling including distance piece and set of</td>
<td>1 set</td>
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</table>
### Steam Generation Plant

**TALCHER FERTILIZERS LIMITED**

**SPARE LIST**

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<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
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<tbody>
<tr>
<td>1.3</td>
<td>Complete set of bearing (each type)</td>
<td>2 sets</td>
</tr>
<tr>
<td>1.4</td>
<td>Complete Set of Seals/ Mechanical seals for process media (each type)</td>
<td>2 set</td>
</tr>
<tr>
<td>1.5</td>
<td>Complete Set of oil seals</td>
<td>200%</td>
</tr>
<tr>
<td>1.6</td>
<td>Complete Set of ‘O’ rings, gaskets, sealing rings, Oil seals for compressor (each type)</td>
<td>200%</td>
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#### 2.0 GEAR BOX

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<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
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<tbody>
<tr>
<td>2.1</td>
<td>Complete set of bearing each type</td>
<td>2 sets</td>
</tr>
<tr>
<td>2.2</td>
<td>Set of spare wheels with shaft</td>
<td>1 set</td>
</tr>
<tr>
<td>2.3</td>
<td>Oil seals, gaskets</td>
<td>200%</td>
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</table>

#### 3.0 COOLERS (Inter cooler / after cooler spares)

<table>
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<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>3.1</td>
<td>Tubes for cooler</td>
<td>1 set of total tubes bundle</td>
</tr>
<tr>
<td>3.2</td>
<td>Gaskets/ end gaskets, O-rings for coolers &amp; press. Vessels</td>
<td>200%</td>
</tr>
<tr>
<td>3.3</td>
<td>Tube Plugs</td>
<td>5% of tube holes</td>
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#### 4.0 LUBE OIL SYSTEM

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<tr>
<td>4.1</td>
<td>Complete set of Lube Oil Pumps with drive</td>
<td>1 set</td>
</tr>
<tr>
<td>4.2</td>
<td>Spares for lube oil pump :</td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>Set of bearings</td>
<td>1 set</td>
</tr>
<tr>
<td>b)</td>
<td>Set of seal</td>
<td>200%</td>
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<tr>
<td>4.3</td>
<td>Lube oil filter cartridges</td>
<td>4 sets</td>
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<td>4.4</td>
<td>Set of Couplings</td>
<td>2 Set</td>
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#### 5.0 ACCESSORIES

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<td>5.1</td>
<td>Spare permanent filters in gas/ air line</td>
<td>2 sets</td>
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#### 6.0 INSTRUMENTATION

As per Instrumentation specification enclosed with enquiry / order specification.

---

### 2.3 Screw Compressor (for air / HVAC services, if applicable)

The mandatory spares to be supplied for each working train /unit shall be as under. No spares considered for standby unit

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
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<tr>
<td>1.1</td>
<td>Completely assembled dynamically balanced spare rotor including clearance check and mechanical run test</td>
<td>1 set</td>
</tr>
<tr>
<td>1.2</td>
<td>Complete spare coupling including distance piece and set of coupling bolts &amp; nuts</td>
<td>1 set</td>
</tr>
<tr>
<td>1.3</td>
<td>Complete Set of Bearings each type</td>
<td>2 set</td>
</tr>
<tr>
<td>1.4</td>
<td>Mechanical seal</td>
<td>1 set</td>
</tr>
<tr>
<td>1.5</td>
<td>Set of ‘O’ rings, gaskets, Oil seals sealing rings etc for compressor</td>
<td>200%</td>
</tr>
</tbody>
</table>

#### 2.0 OIL SYSTEM

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Complete set of Lube Oil Pumps with drive as applicable</td>
<td>1 set</td>
</tr>
<tr>
<td>2.2</td>
<td>Spares for lube oil pump :</td>
<td></td>
</tr>
<tr>
<td>a) Set of bearings</td>
<td>1 set</td>
<td></td>
</tr>
<tr>
<td>b) Set of seal</td>
<td>200%</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>Lube oil filter cartridges</td>
<td>4 sets</td>
</tr>
<tr>
<td>2.4</td>
<td>Set of Couplings</td>
<td>2 Set</td>
</tr>
</tbody>
</table>

#### 3.0 GEAR BOX

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Complete set of bearing each type</td>
<td>2 sets</td>
</tr>
</tbody>
</table>
### 2.4 Centrifugal Fan (FD / ID Fan)

The mandatory spares to be supplied for each working train/unit shall be as under. No spares considered for standby unit.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Completely dynamically balanced rotor assembly including impeller, wheel, key etc.</td>
<td>1 Set</td>
</tr>
<tr>
<td>2.0</td>
<td>Shaft sleeve</td>
<td>1 Set</td>
</tr>
<tr>
<td>3.0</td>
<td>Bearings</td>
<td>2 Sets</td>
</tr>
<tr>
<td>4.0</td>
<td>Stuffing box packing rings sets (DE/ NDE)</td>
<td>200 %</td>
</tr>
<tr>
<td>5.0</td>
<td>Complete set of all Gasket &amp; ‘O’ rings</td>
<td>200 %</td>
</tr>
<tr>
<td>6.0</td>
<td>Complete mechanical seal , if applicable</td>
<td>1 set</td>
</tr>
<tr>
<td>8.0</td>
<td>Coupling bushes</td>
<td>2 Set</td>
</tr>
<tr>
<td>9.0</td>
<td>Complete coupling with elements</td>
<td>1 Set</td>
</tr>
<tr>
<td>10.0</td>
<td>All type of Fasteners</td>
<td>200%</td>
</tr>
</tbody>
</table>

### 2.6 Steam Turbine

The mandatory spares to be supplied for each working train/unit shall be as under. No spares considered for standby unit.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Turbine</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Completely assembled dynamically balanced rotor</td>
<td>1 set</td>
</tr>
<tr>
<td>1.2</td>
<td>Discharge assembly</td>
<td>1 set</td>
</tr>
<tr>
<td>1.3</td>
<td>Inlet nozzles</td>
<td>1 set</td>
</tr>
<tr>
<td>1.3</td>
<td>Complete set of Journal bearing with internals</td>
<td>1 set</td>
</tr>
<tr>
<td>1.4</td>
<td>Complete set of Journal bearing Pads</td>
<td>2 set</td>
</tr>
<tr>
<td>1.5</td>
<td>Complete set of Thrust bearing with internals</td>
<td>1 set</td>
</tr>
<tr>
<td>1.6</td>
<td>Complete set of Thrust bearing Pads</td>
<td>2 set</td>
</tr>
<tr>
<td>1.8</td>
<td>Shaft seal carbon labyrinth</td>
<td>2 sets</td>
</tr>
<tr>
<td>1.9</td>
<td>Labyrinth seal</td>
<td>2 sets</td>
</tr>
<tr>
<td>1.10</td>
<td>Complete coupling ( turbine &amp; gear box)</td>
<td>1 set</td>
</tr>
<tr>
<td>1.11.1</td>
<td>Coupling bolts, nuts&amp; washer</td>
<td>200 %</td>
</tr>
<tr>
<td>1.11.2</td>
<td>Coupling shims</td>
<td>1 set</td>
</tr>
<tr>
<td>1.11.3</td>
<td>Rubber bush for coupling</td>
<td>1 set</td>
</tr>
<tr>
<td>1.12</td>
<td>Governor assembly</td>
<td>1 set</td>
</tr>
<tr>
<td>1.13</td>
<td>Control valve &amp; servo spares</td>
<td>1 set</td>
</tr>
<tr>
<td>1.14</td>
<td>Emergency stop valve spare / pilot valve spare</td>
<td>1 set</td>
</tr>
<tr>
<td>1.15</td>
<td>Over speed trip spare</td>
<td>1 set</td>
</tr>
<tr>
<td>1.16</td>
<td>Thrust collar assembly</td>
<td>1 set</td>
</tr>
<tr>
<td>S. No.</td>
<td>DESCRIPTION</td>
<td>QUANTITY</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>1.20</td>
<td>Complete set of all type Oil seals, o-rings &amp; gaskets</td>
<td>200 %</td>
</tr>
<tr>
<td>1.21</td>
<td>All type of Fasteners</td>
<td>200%</td>
</tr>
<tr>
<td>1.22</td>
<td>Inner Casing</td>
<td>1 set</td>
</tr>
<tr>
<td>1.23</td>
<td>Guide blade carriers</td>
<td>1 set</td>
</tr>
</tbody>
</table>

2.0 Gear Box Spares

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Pinion &amp; gears</td>
<td>1 set</td>
</tr>
<tr>
<td>2.2</td>
<td>Bearings</td>
<td>1 set</td>
</tr>
<tr>
<td>2.3</td>
<td>Shaft seal</td>
<td>2 sets</td>
</tr>
<tr>
<td>2.4</td>
<td>'O' ring, gaskets, Oil seals</td>
<td>200 %</td>
</tr>
</tbody>
</table>

3.0 Lube Oil System

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Complete set of Lube Oil Pumps (MOP/AOP/EOP) including jacking oil pumps with their drives</td>
<td>1 set</td>
</tr>
<tr>
<td>3.5</td>
<td>Mech. seal complete</td>
<td>1 set</td>
</tr>
<tr>
<td>3.6</td>
<td>Spare for mech. seal</td>
<td>1 set</td>
</tr>
<tr>
<td>3.6.1</td>
<td>'O' ring, gaskets</td>
<td>200 %</td>
</tr>
<tr>
<td>3.7</td>
<td>Coupling</td>
<td>2 sets</td>
</tr>
<tr>
<td>3.10</td>
<td>Relief valve assembly</td>
<td>1 set</td>
</tr>
<tr>
<td>3.11</td>
<td>Plug &amp; seat for relief valve</td>
<td>1 set</td>
</tr>
<tr>
<td>3.12</td>
<td>Spring &amp; stem for PSV</td>
<td>1 set</td>
</tr>
<tr>
<td>3.13.1</td>
<td>Set of gaskets for each cooler</td>
<td>2 sets</td>
</tr>
<tr>
<td>3.13.2</td>
<td>Lube oil filter cartridges</td>
<td>3 sets</td>
</tr>
<tr>
<td>3.13.3</td>
<td>Relief valve</td>
<td>1 set</td>
</tr>
<tr>
<td>3.13.4</td>
<td>Safety valve plug seal</td>
<td>1 set</td>
</tr>
</tbody>
</table>

2.7 Centrifugal Pump

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Impeller</td>
<td>1 set</td>
</tr>
<tr>
<td>2</td>
<td>Impeller locking nut</td>
<td>2 sets</td>
</tr>
<tr>
<td>3</td>
<td>Wear Rings</td>
<td>1 set</td>
</tr>
<tr>
<td>4</td>
<td>Shaft with keys</td>
<td>1 No.</td>
</tr>
<tr>
<td>5</td>
<td>Shaft Sleeve</td>
<td>1 set</td>
</tr>
<tr>
<td>6</td>
<td>Interstage sleeves</td>
<td>1 set</td>
</tr>
<tr>
<td>7</td>
<td>Interstage Bushes</td>
<td>1 set</td>
</tr>
<tr>
<td>8</td>
<td>Mech. Seal where applicable</td>
<td>1 no.</td>
</tr>
<tr>
<td>9</td>
<td>'O' Rings / Springs for Mech. Seal</td>
<td>2 set</td>
</tr>
<tr>
<td>10</td>
<td>Mechanical Seal Faces</td>
<td>1 set</td>
</tr>
<tr>
<td>11</td>
<td>Constant level Oiler</td>
<td>2 sets</td>
</tr>
<tr>
<td>12</td>
<td>Deflectors</td>
<td>2 sets</td>
</tr>
<tr>
<td>13</td>
<td>Complete coupling</td>
<td>1 No.</td>
</tr>
<tr>
<td>14</td>
<td>Flexible elements, Bushes, Pins for Coupling</td>
<td>1 set</td>
</tr>
</tbody>
</table>
### STEAM GENERATION PLANT
**TALCHER FERTILIZERS LIMITED**

**SPARE LIST**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
<th>No. of Pumps working</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>All type of Bearings</td>
<td>1 set</td>
<td>2 sets</td>
</tr>
<tr>
<td>16</td>
<td>Gaskets &amp; 'O' Rings</td>
<td>2 sets</td>
<td>3 sets</td>
</tr>
<tr>
<td>17</td>
<td>Labyrinths</td>
<td>2 sets</td>
<td>3 sets</td>
</tr>
<tr>
<td>18</td>
<td>Throat Bushing</td>
<td>1 No.</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>19</td>
<td>Throttle Bushing</td>
<td>1 No.</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>20</td>
<td>Oil Seals</td>
<td>2 sets</td>
<td>3 sets</td>
</tr>
<tr>
<td>21</td>
<td>Balancing drum &amp; sleeves</td>
<td>1 set</td>
<td>1 set</td>
</tr>
<tr>
<td>22</td>
<td>Leak-off valve-gaskets, 'O' Rings and springs</td>
<td>2 sets</td>
<td>3 sets</td>
</tr>
<tr>
<td>23</td>
<td>Spares for gear box (bearings, gears and seals)</td>
<td>1 set</td>
<td>1 set</td>
</tr>
<tr>
<td>24</td>
<td>All type of Bearings and Oil filter elements for variable hydraulic Turbo coupling (if applicable)</td>
<td>1 set</td>
<td>2 sets</td>
</tr>
<tr>
<td>25</td>
<td>All type of Fasteners</td>
<td>200%</td>
<td>200%</td>
</tr>
</tbody>
</table>

#### 2.8 Reciprocating Pump

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
<th>No. of Pumps working</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**A MAIN FRAME**

1. Main Bearings | 1 set | 1 set | 1 set | 1 set |
2. Big End Bearings | 1 set | 1 set | 1 set | 1 set |
3. Thrust Bearings | 1 set | 1 set | 2 sets | 2 sets |
4. Crosshead shoes | 1 set | 1 set | 1 set | 1 set |
5. Crosshead bushes | 1 set | 1 set | 1 set | 1 set |
6. Connecting rod bolts complete with nuts | 4 Nos. | 4 Nos. | 6 Nos. | 6 Nos. |
7. Crank shaft | 1 No. | 1 No. | 1 No. | 1 No. |
8. Lube oil pump (w/o motor) | 1 No. | 1 No. | 1 No. | 1 No. |
9. Spare parts for lube oil pump (set of gears, bushes, gaskets etc.) | 1 set | 1 set | 2 sets | 2 sets |
10. Cartridge for oil filter. | 2 Nos. | 2 Nos. | 4 Nos. | 4 Nos. |
11. Special gaskets, oil seals, 'O' rings, special bolts etc. | 2 sets | 2 sets | 4 sets | 4 sets |
12. Complete set of coupling with fasteners | 1 set | 1 set | 1 set | 1 set |

**B FLUID END**

1. Cylinders | 1 No. | 1 No. | 2 Nos. | 2 Nos. |
2. Plungers / piston & piston rod assembly, piston rings (if applicable) | 1 set | 1 set | 1 set | 1 set |
3. Stuffing box Packings | 2 sets | 2 sets | 4 sets | 4 sets |
4. Plunger Packings | 2 sets | 2 sets | 4 sets | 4 sets |
5. Suction valve & seat | 1 set | 2 sets | 3 sets | 4 sets |
6. Discharge valve & seat | 1 set | 2 sets | 3 sets | 4 sets |
7. Flushing pump (if applicable) | 1 No. | 1 No. | 1 No. | 1 No. |
8. Spares for flushing pump. | 1 set | 1 set | 2 sets | 2 sets |
- Plunger
- Plunger Packings
- Valves
<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No. of Pumps working</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>9.</td>
<td>Special gaskets, springs, ‘O’ rings, and ring nuts for stuffing box packing, cylinder bolts.</td>
<td>2 sets</td>
</tr>
</tbody>
</table>

**C GEAR REDUCER (IF APPLICABLE)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>No. of Pumps working</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1.</td>
<td>Oil seals</td>
<td>2 set</td>
</tr>
<tr>
<td>2.</td>
<td>Lube oil pump</td>
<td>1 No.</td>
</tr>
<tr>
<td>3.</td>
<td>Spare parts for lube oil pump-gears, bushes, gaskets etc</td>
<td>1 set</td>
</tr>
</tbody>
</table>

**D LUBE OIL COOLERS (IF APPLICABLE)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>No. of Pumps working</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1.</td>
<td>Complete Set of gaskets, o-rings if any</td>
<td>2 sets</td>
</tr>
<tr>
<td>2.</td>
<td>Set of tube bundles</td>
<td>100%</td>
</tr>
</tbody>
</table>

### 2.9 Metering Pump

<table>
<thead>
<tr>
<th>S. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No. of Pumps working</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

**A POWER END**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>No. of Pumps working</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1.</td>
<td>Main Bearings</td>
<td>1 set</td>
</tr>
<tr>
<td>2.</td>
<td>Big End Bearings</td>
<td>1 set</td>
</tr>
<tr>
<td>3.</td>
<td>Crosshead shoes</td>
<td>1 set</td>
</tr>
<tr>
<td>4.</td>
<td>Crosshead bushes</td>
<td>1 set</td>
</tr>
<tr>
<td>5.</td>
<td>Connecting rod bolts complete with nuts</td>
<td>200%</td>
</tr>
<tr>
<td>6.</td>
<td>Special gaskets, oil seals, ‘O’ rings, special bolts etc.</td>
<td>2 sets</td>
</tr>
<tr>
<td>7.</td>
<td>Complete set of coupling with fasteners</td>
<td>1 set</td>
</tr>
</tbody>
</table>

**B FLUID END**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>No. of Pumps working</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1.</td>
<td>Cylinders</td>
<td>1 No.</td>
</tr>
<tr>
<td>2.</td>
<td>Plungers</td>
<td>1 set</td>
</tr>
<tr>
<td>3.</td>
<td>Diaphragm</td>
<td>1 set</td>
</tr>
<tr>
<td>4.</td>
<td>Stuffing box Packings</td>
<td>2 sets</td>
</tr>
<tr>
<td>5.</td>
<td>Suction valves &amp; seats</td>
<td>1 set</td>
</tr>
<tr>
<td>6.</td>
<td>Discharge valves &amp; seats</td>
<td>1 set</td>
</tr>
<tr>
<td>7.</td>
<td>All gaskets, springs, ‘O’ rings, ring nuts for stuffing_box packing, cylinder bolts</td>
<td>200%</td>
</tr>
</tbody>
</table>

### 2.10 Agitator

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>DESCRIPTION</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No. of Agitator working</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1.</td>
<td>Complete set of all Bearings</td>
<td>1 set</td>
</tr>
<tr>
<td>2.</td>
<td>Complete set of impeller blades of each type with set of fasteners.</td>
<td>1 set</td>
</tr>
<tr>
<td>3.</td>
<td>Complete set of High speed flexible coupling with bushes / elements.</td>
<td>1 set</td>
</tr>
<tr>
<td>4.</td>
<td>High speed Coupling bushes</td>
<td>3 sets</td>
</tr>
</tbody>
</table>
5. Complete set of Low speed flexible coupling with bushes / elements. | 1 set | 1 set | 1 set | 1 set
6. Low speed Coupling bushes | 3 sets | 3 sets | 4 Sets | 4 Sets
7. Complete set of all Oil seal for gear box | 1 set | 1 set | 1 set | 1 set
8. Complete set of all Oil seal for bearing housing | 4 set | 4 set | 6 set | 6 set
9. Complete set of Seal packing. | 2 sets | 2 sets | 4 sets | 4 sets

### 2.11 EOT Cranes:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Wire rope for main hoist</td>
<td>1 set</td>
</tr>
<tr>
<td>2.</td>
<td>Wire rope for Auxiliary hoist</td>
<td>1 set</td>
</tr>
<tr>
<td>3.</td>
<td>Rope guide for main Hoist</td>
<td>1 set</td>
</tr>
<tr>
<td>4.</td>
<td>Rope guide for Auxiliary Hoist</td>
<td>1 set</td>
</tr>
<tr>
<td>5.</td>
<td>Brake linings of each type</td>
<td>2 sets</td>
</tr>
<tr>
<td>6.</td>
<td>Gear sets</td>
<td>2 sets</td>
</tr>
<tr>
<td>7.</td>
<td>All type of Bearings</td>
<td>2 sets</td>
</tr>
<tr>
<td>8.</td>
<td>All type of Seal, Gaskets, O-rings</td>
<td>2 sets</td>
</tr>
</tbody>
</table>

**NOTE:**
1. ‘Set’ means complete replacement of particular part in one machine.
2. The quotation should contain sectional drawing showing location & part no. (For exact identification) & material specification

### 2.12 Static Equipments / Boiler:

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Spare Items</th>
<th>Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Heat Exchangers – Shell &amp; Tube: (U-tube included Each type)</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Bolts</td>
<td>10% of total for each type/size (minimum 2 pieces of each type/size)</td>
</tr>
<tr>
<td>1.2</td>
<td>Gaskets</td>
<td>200% of each type/size</td>
</tr>
<tr>
<td>1.3</td>
<td>Tube Plug</td>
<td>5% of tube holes</td>
</tr>
<tr>
<td>2.0</td>
<td>Pressure Vessels - Each type</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Gaskets</td>
<td>200% of each type/size</td>
</tr>
<tr>
<td>2.2</td>
<td>Bolts</td>
<td>10% of total for each type/size (minimum 2 pieces of each type/size)</td>
</tr>
<tr>
<td>2.3</td>
<td>Spare for internals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clamps</td>
<td>10% of total for each type / size (minimum 2 nos. of each size)</td>
</tr>
<tr>
<td></td>
<td>Washer</td>
<td>10% of total for each type / size (minimum 2 nos. of each size)</td>
</tr>
<tr>
<td></td>
<td>Bubble Caps / valve</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Gaskets</td>
<td>200% of each type/size</td>
</tr>
<tr>
<td></td>
<td>Asbestos Tape Gasket for trays</td>
<td>Gasket 25% excess (min. 3 pieces)</td>
</tr>
<tr>
<td>2.4</td>
<td>Sight glass</td>
<td>300%</td>
</tr>
<tr>
<td>2.5</td>
<td>Filter Cartridge/ Elements</td>
<td>200%</td>
</tr>
<tr>
<td>3.0</td>
<td>Air Cooled Exchangers</td>
<td></td>
</tr>
</tbody>
</table>
### STEAM GENERATION PLANT
### TALCHER FERTILIZERS LIMITED
### SPARE LIST

#### 3.0 Plugs
- Steel 1%; Non-ferrous 2% (minimum 1 number)

#### 3.2 Plug gaskets
- 5% (minimum 1 number)

#### 3.3 Cover plate gaskets
- 100%

#### 3.4 Tube support boxes
- 10% (minimum 1 number)

### 4.0 Number of Air-fin coolers using part

<table>
<thead>
<tr>
<th>Spare items</th>
<th>Qty.</th>
<th>Qty.</th>
<th>Qty.</th>
<th>Qty.</th>
<th>Qty.</th>
<th>Qty.</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 V-belts-sheaves (Driven &amp; driver)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Set of belts</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>4.2 Fan Shaft Bearing (Upper &amp; Lower)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>50% of no. of air fins.</td>
</tr>
<tr>
<td>4.3 Speed Reducers (Gear box) Shaft &amp; pinion</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>30% of no. of air fins.</td>
</tr>
<tr>
<td>4.4 Bearing Set O-rings, seals, lock washers, locknuts</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>50% of no. of air fins.</td>
</tr>
<tr>
<td>4.5 Couplings – Complete coupling, flanges, gaskets and seals</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4.6 Fan Assemblies, Automatic pitch control, Hub assembly parts, guide bushing, pitch blocks, O-rings, Clam gaskets</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>100% of no. of air fins</td>
</tr>
<tr>
<td>4.7 Bolt assemblies, fork pins</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>100% of no. of air fins</td>
</tr>
<tr>
<td>4.8 Flexible hose, rotary union</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4.9 Automatic or manual adjustments: Blade retention clamps, pitch, change forks, punch rods, stub (with pilot tubes) bearing retainer rings</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>30% of no. of air fins</td>
</tr>
<tr>
<td>4.10 Spring housing gasket, Diaphragm, blade retainer ring, Thrust cover gasket</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>20% of no. of air fins</td>
</tr>
</tbody>
</table>

### 5.0 Plate type Exchanger (Each type)

<table>
<thead>
<tr>
<th></th>
<th>Qty.</th>
<th>Qty.</th>
<th>Qty.</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Plate gasket</td>
<td>10 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.2 Flow plate</td>
<td>10 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.3 Nozzle gasket</td>
<td>200 %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.4 Glue (1 kg pot)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.5 Special spanner tool</td>
<td>1 for each size/ type</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 6.0 TANKS

<table>
<thead>
<tr>
<th></th>
<th>Qty.</th>
<th>Qty.</th>
<th>Qty.</th>
<th>Qty.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1 Gasket for each nozzle having blind flange</td>
<td>200%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.2 Internal &amp; external bolting for each connection</td>
<td>10% (Min. 4 pieces)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 7.0 STEAM GENERATOR AND AUXILIARIES

#### 7.1 Steam drum
- Manhole Cover Gaskets 200 % of each type/size

#### 7.2 Furnace Water Wall
- Tube in Straight lengths (6m straight length of each type) 10 nos.

#### 7.3 Economiser/Hanger Tubes
- Tube in Straight lengths (6m straight length of each type) 6 nos.

#### 7.4 Super heaters
- Tube in Straight lengths (6m straight length of each type) 6 nos.

#### 7.5 Air heaters

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<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Part Description</th>
<th>Size Range (NB)</th>
<th>Quantity Required (% of as built)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pipes &amp; Fittings</td>
<td>≤1.5”</td>
<td>5%</td>
<td>min. qty. 6 mtr. / 1 No.</td>
</tr>
<tr>
<td>2</td>
<td>Pipes &amp; Fittings</td>
<td>≥2”</td>
<td>2%</td>
<td>min. qty. 6 mtr. / 1 No.</td>
</tr>
<tr>
<td>3</td>
<td>Flanges</td>
<td>≤1.5”</td>
<td>5%</td>
<td>min. qty. 1 No.</td>
</tr>
<tr>
<td>4</td>
<td>Flanges</td>
<td>2” to 6”</td>
<td>5%</td>
<td>min. qty. 1 No.</td>
</tr>
<tr>
<td>5</td>
<td>Flanges</td>
<td>8” to 36”</td>
<td>2%</td>
<td>min. qty. 1 No.</td>
</tr>
<tr>
<td>6</td>
<td>Valves</td>
<td>≤1.5”</td>
<td>5%</td>
<td>min. qty. 1 No.</td>
</tr>
<tr>
<td>7</td>
<td>Valves</td>
<td>2” to 14”</td>
<td>5%</td>
<td>min. qty. 1 No.</td>
</tr>
<tr>
<td>8</td>
<td>Valves</td>
<td>≥16” with rating ≥900#</td>
<td></td>
<td>Note-5</td>
</tr>
<tr>
<td>9</td>
<td>Bolts, Nuts &amp; Gaskets (For each size, rating, material)</td>
<td></td>
<td>10%</td>
<td>min. qty. 1 No.</td>
</tr>
<tr>
<td>10</td>
<td>Traps (For each size, rating, material)</td>
<td></td>
<td>2%</td>
<td>min. qty. 1 No.</td>
</tr>
<tr>
<td>11</td>
<td>Expansion Bellow (For each size, rating, material)</td>
<td></td>
<td>10%</td>
<td>min. qty. 1 No.</td>
</tr>
<tr>
<td>12</td>
<td>Strainer element (For each size, rating, material)</td>
<td></td>
<td>10%</td>
<td>min. qty. 1 No.</td>
</tr>
<tr>
<td>13</td>
<td>Complete Gear Box for gear operated Valves</td>
<td></td>
<td>5%</td>
<td>min. qty. 1 No.</td>
</tr>
<tr>
<td>14</td>
<td>Seal ring for the Pressure seal type valves</td>
<td></td>
<td>5%</td>
<td>min. qty. 10 Nos.</td>
</tr>
<tr>
<td>15</td>
<td>Hose assembly</td>
<td></td>
<td>50%</td>
<td>min. qty. 10 Nos.</td>
</tr>
</tbody>
</table>

Notes:
1) Quantities shown are for each size and type of part.
2) The parts listed are the principal parts only. Other parts shall be considered for recommendation in quantities consistent with the above table.
3) All special tools and tackles required for maintenance for critical items shall be supplied along with equipment.

2.13 Piping Items:
Following spares are to be supplied for the Piping Bulk Materials:
### Notes (Piping items):
1. Percent of quantity required as mandatory spares is for each and every item/size/material consumed in as built.
2. No substitution in size, rating and material is allowed.
3. Pipe length in meter and other items in No. or Set shall be supplied.
4. Fractional part of quantity shall be converted into nearest upward whole part.
5. For rating ≥900# and sizes ≥16”, minimum one qty. valve spare shall be supplied for each size, rating & material.

### Electrical Items:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Paging Equipment / Public Address System</td>
<td></td>
</tr>
<tr>
<td>A.</td>
<td>Field station each type</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>B.</td>
<td>Operator console</td>
<td>1 No.</td>
</tr>
<tr>
<td>C.</td>
<td>Loud speaker each type</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>D.</td>
<td>Driver unit for loud speaker each type</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>E.</td>
<td>Microphone unit of field station</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>F.</td>
<td>Amplifier assembly</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>G.</td>
<td>Power Supply Unit</td>
<td>1 Set</td>
</tr>
<tr>
<td>H.</td>
<td>Main Call Station</td>
<td>1 No.</td>
</tr>
<tr>
<td>I.</td>
<td>PCBs of each type</td>
<td>1 No.</td>
</tr>
<tr>
<td>2.0</td>
<td>UPS of Each Rating</td>
<td></td>
</tr>
<tr>
<td>A.</td>
<td>Semiconductor Fuses or HRC Fuse Links of each rating</td>
<td>30%</td>
</tr>
</tbody>
</table>
### Sr. No. | Item | Quantity
--- | --- | ---
B. | MCB, MCCB and control switches of each rating | 1 Set
C. | SCR, diodes and transistors of each type | 50%
D. | Capacitors, resistors and chokes of each type | 50%
E. | Signal Lamps of each colour & voltage | 30%
F. | Control Cards | 1 Set
G. | Semiconductor fuses & HRC fuse links of each type | 1 Set
H. | IGBT of each type | 1 Set
I. | Software and programming terminal | 1 Set
J. | Batteries | 5 cells
K. | Isolator switch of each type | 1 No.
L. | Ventilation Fan each type | 2 Nos.
M. | PCBs of each type | 1 No.
N. | Electrolyte | 10%

### 3.0 Power and Distribution Transformer (of each type & rating)

A. | HV Bushing complete with metal parts for all 3 phases | 1 Set
B. | LV Bushing complete with metal parts for all 3 phases | 1 Set
C. | Neutral Bushing complete with metal parts | 1 Set
D. | NCTs of each type | 1 No.
E. | Complete set of Gaskets | 1 Set
F. | Complete set of valves (1 no of each type) | 1 Set
G. | Radiator | 1 No.
H. | PRV with alarm and trip contacts | 1 Set
I. | Explosion vent diaphragm | 1 No.
J. | Oil level gauge | 1 No.
K. | Complete charge of silica gel with breather | 2 Sets
L. | Gland packing / O-ring for every valve | 1 Set
M. | Buchhloz relay | 1 No.
N. | Analog type OTI | 1 No.
O. | Analog type WTI | 1 No.
P. | CT for WTI | 1 No.
Q. | Magnetic oil level gauge | 1 No.
R. | Dial type thermometer | 1 No.
S. | Sealing/gauge glass of conservator | 1 No.
T. | Oil (% extra of total transformer oil) | 10%
U. | Miscellaneous spares (control switches, fuses lamps) for Marshalling Box | 2 Sets
V. | Cooler Fan with Motor | 1 No.
W. | Remote tap position indicator | 1 No.
X. | Oil surge relay for OLTC | 1 No.
Y. | Starter contactors, switches and relays for electrical control panels | 1 Set

### 4.0 Neutral Earthing Resistor (of each rating)
A. | Bushing with accessories | 1 Set
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.</td>
<td>Support Insulators</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>C.</td>
<td>Bushing Insulator</td>
<td>1 No.</td>
</tr>
<tr>
<td>D.</td>
<td>Resistor Element</td>
<td>20% minimum one cartridge per type</td>
</tr>
</tbody>
</table>

5.0 Each 11 kV Switchboard and 3.3 kV Switchboard

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Complete VCB (ready to use) of each rating</td>
<td>1 No.</td>
</tr>
<tr>
<td>B.</td>
<td>Trip bar spring and any other spring used in the circuit breaker mechanism for breaker of each rating</td>
<td>1 No.</td>
</tr>
<tr>
<td>C.</td>
<td>Shunt trip coil for breaker of each rating</td>
<td>10%</td>
</tr>
<tr>
<td>D.</td>
<td>Closing coil for breaker of each rating</td>
<td>10%</td>
</tr>
<tr>
<td>E.</td>
<td>Spring charging motor of each rating</td>
<td>1 No.</td>
</tr>
<tr>
<td>F.</td>
<td>Spring charging handle for breaker of each rating</td>
<td>1 No.</td>
</tr>
<tr>
<td>G.</td>
<td>Racking out handles for breaker of each rating</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Quantity</td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>H</td>
<td>Secondary Isolating contact blocks for breaker of each rating</td>
<td>1 No.</td>
</tr>
<tr>
<td>I</td>
<td>Micro Switch for Test/Service Position for breaker of each rating</td>
<td>1 No.</td>
</tr>
<tr>
<td>J</td>
<td>Micro Switch for Spring Charging for breaker of each rating</td>
<td>1 No.</td>
</tr>
<tr>
<td>K</td>
<td>Main contact sets/Jaw contact compete for breaker of each rating</td>
<td>1 Set</td>
</tr>
<tr>
<td>L</td>
<td>Trip-Neutral-Close Control Switch</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>M</td>
<td>Local-OFF-Remote Selector Switch</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>N</td>
<td>Ammeter Selector Switch</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>O</td>
<td>Voltmeter Selector Switch</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>P</td>
<td>Push Button Element of each type &amp; rating</td>
<td>20 %</td>
</tr>
<tr>
<td>Q</td>
<td>Push Button Actuator of each type</td>
<td>20 %</td>
</tr>
<tr>
<td>R</td>
<td>Trip Selector Switch</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>S</td>
<td>Panel limit switches &amp; interlocking switches</td>
<td>10% each type</td>
</tr>
<tr>
<td>T</td>
<td>Panel operating switches (all types)</td>
<td>1 Set each</td>
</tr>
<tr>
<td>U</td>
<td>Breaker limit switches &amp; interlocking switches</td>
<td>10% each type</td>
</tr>
<tr>
<td>V</td>
<td>Protection Relays for different type of feeders i.e Incoming Feeder, Bus-coupler Feeder, Outgoing feeder, Motor Feeder, Transformer Feeder etc.</td>
<td>1 No. for each type of feeder</td>
</tr>
<tr>
<td>W</td>
<td>Trip relays of each type</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>X</td>
<td>Auxiliary Relays of each Type</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>Y</td>
<td>Miniature Circuit Breaker of each type &amp; rating</td>
<td>20 %</td>
</tr>
<tr>
<td>Z</td>
<td>Meters (of each type &amp; rating)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Ammeter</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>ii) Voltmeter</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>iii) Multifunction Meter</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>iv) Energy Meter</td>
<td>1 No.</td>
</tr>
<tr>
<td>AA</td>
<td>Instrument Transformers of each type &amp; rating</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) CT</td>
<td>3 Nos.</td>
</tr>
<tr>
<td></td>
<td>ii) PT</td>
<td>1 Nos.</td>
</tr>
<tr>
<td>BB</td>
<td>Fuses of each type &amp; rating</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) HRC HV for VT</td>
<td>20 %</td>
</tr>
<tr>
<td></td>
<td>ii) HRC LV</td>
<td>20 %</td>
</tr>
<tr>
<td>CC</td>
<td>Alarm bell</td>
<td>1 No.</td>
</tr>
<tr>
<td>DD</td>
<td>Alarm buzzer</td>
<td>1 No.</td>
</tr>
<tr>
<td>EE</td>
<td>Lamp Complete assembly of each colour&amp; voltage</td>
<td>10%</td>
</tr>
<tr>
<td>FF</td>
<td>Current transducers of each rating</td>
<td>20%</td>
</tr>
<tr>
<td>GG</td>
<td>Voltage transducers of each rating</td>
<td>20%</td>
</tr>
<tr>
<td>HH</td>
<td>Power Transducers of each rating</td>
<td>20%</td>
</tr>
<tr>
<td>II</td>
<td>Bus-Bar Support Insulators</td>
<td>1 Set</td>
</tr>
<tr>
<td>JJ</td>
<td>Surge Arrestors</td>
<td>1 No.</td>
</tr>
<tr>
<td>KK</td>
<td>Inspection Glass</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>LL</td>
<td>Sprouts</td>
<td>1 Set</td>
</tr>
<tr>
<td>MM</td>
<td>Panel Space Heaters with Thermostat</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>NN</td>
<td>Alarm Annunciator of each type</td>
<td>1 No.</td>
</tr>
<tr>
<td>OO</td>
<td>Interpanel insulation barriers</td>
<td>20% Minimum 1 No.</td>
</tr>
<tr>
<td>PP</td>
<td>Earthing Trolley</td>
<td>1 No.</td>
</tr>
<tr>
<td>QQ</td>
<td>Maintenance Trolley for breaker of all rating</td>
<td>1 No.</td>
</tr>
<tr>
<td>RR</td>
<td>Set of gaskets for all ratings &amp; type</td>
<td>1 Set</td>
</tr>
<tr>
<td>SS</td>
<td>Panel shutter assembly</td>
<td>2 No.</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Quantity</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>TT</td>
<td>Removable bus bar shrouds</td>
<td>1 Set</td>
</tr>
<tr>
<td>UU</td>
<td>Bus bar mounted power fix contacts</td>
<td>1 Set</td>
</tr>
<tr>
<td></td>
<td><strong>6.0</strong> Each LT (415V) Switchboard (PMCC/PCC/MCC/ASDB/DCDB/UPSDB)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A. Complete ACB (ready to use) of each rating</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>B. Trip coils for breaker of each rating</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>C. Closing coils for breaker of each rating</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>D. Spring charging motors of each rating</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>E. Secondary Isolating contact blocks for breaker of each rating</td>
<td>1 Set</td>
</tr>
<tr>
<td></td>
<td>F. Arcing contacts &amp; arcing chutes block for breaker of each rating</td>
<td>1 Set</td>
</tr>
<tr>
<td></td>
<td>G. Main contact sets/ Jaw contact compete for breaker of each rating</td>
<td>1 Sets</td>
</tr>
<tr>
<td></td>
<td>H. Trip-Neutral-Close Control Switch</td>
<td>2 Nos.</td>
</tr>
<tr>
<td></td>
<td>I. Local-OFF-Remote Selector Switch</td>
<td>2 Nos.</td>
</tr>
<tr>
<td></td>
<td>J. Ammeter Selector Switch</td>
<td>2 Nos.</td>
</tr>
<tr>
<td></td>
<td>K. Voltmeter Selector Switch</td>
<td>2 Nos.</td>
</tr>
<tr>
<td></td>
<td>L. Push Button Element of each type &amp; rating</td>
<td>20 %</td>
</tr>
<tr>
<td></td>
<td>M. Push Button Actuator of each type</td>
<td>20 %</td>
</tr>
<tr>
<td></td>
<td>N. Trip Selector Switch</td>
<td>2 Nos.</td>
</tr>
<tr>
<td></td>
<td>O. Panel limit switches &amp; interlocking switches</td>
<td>10% each type</td>
</tr>
<tr>
<td></td>
<td>P. Panel operating switches (all types)</td>
<td>1 Set each</td>
</tr>
<tr>
<td></td>
<td>Q. Breaker limit switches &amp; interlocking switches</td>
<td>10% each type</td>
</tr>
<tr>
<td></td>
<td>R. Protection Relays for different type of feeders i.e Incoming Feeder, Buscoupler Feeder, Outgoing feeder, Motor Feeder etc.</td>
<td>1 No. for each type of feeder</td>
</tr>
<tr>
<td></td>
<td>S. Trip relays of each type</td>
<td>2 Nos</td>
</tr>
<tr>
<td></td>
<td>T. Auxiliary Relays of each Type</td>
<td>2 Nos</td>
</tr>
<tr>
<td></td>
<td>U. Thermal over Load Relay of each rating</td>
<td>2 Nos</td>
</tr>
<tr>
<td></td>
<td>V. Contactors of each type &amp; rating</td>
<td>2 Nos</td>
</tr>
<tr>
<td></td>
<td>W. Coils for Contactors – each type/voltage</td>
<td>2 Nos</td>
</tr>
<tr>
<td></td>
<td>X. ELCB &amp; RCBO of each type</td>
<td>2 Nos</td>
</tr>
<tr>
<td></td>
<td>Y. Miniature Circuit Breaker of each type &amp; rating</td>
<td>20 %</td>
</tr>
<tr>
<td></td>
<td>Z. SFU of each rating</td>
<td>20 %</td>
</tr>
<tr>
<td>AA</td>
<td>Meters (of each type &amp; rating)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) Ammeter</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>ii) Voltmeter</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>iii) Multifunction Meter</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>iv) Energy Meter</td>
<td>1 No.</td>
</tr>
<tr>
<td>BB</td>
<td>Instrument Transformers of each type &amp; rating</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i) CT</td>
<td>3 Nos.</td>
</tr>
<tr>
<td></td>
<td>ii) PT</td>
<td>1 Nos.</td>
</tr>
<tr>
<td>CC</td>
<td>Fuses of of each type &amp; rating</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HRC LV</td>
<td>20 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>DD.</td>
<td>Alarm bell</td>
<td>1 No.</td>
</tr>
<tr>
<td>EE.</td>
<td>Alarm buzzer</td>
<td>1 No.</td>
</tr>
<tr>
<td>FF.</td>
<td>Lamp Complete assembly of each colour &amp; voltage</td>
<td>10%</td>
</tr>
<tr>
<td>GG.</td>
<td>Current transducers of each rating</td>
<td>20%</td>
</tr>
<tr>
<td>HH.</td>
<td>Voltage transducers of each rating</td>
<td>20%</td>
</tr>
<tr>
<td>II.</td>
<td>Power Transducers of each rating</td>
<td>20%</td>
</tr>
<tr>
<td>JJ.</td>
<td>Bus-Bar Support Insulators</td>
<td>1 Set</td>
</tr>
<tr>
<td>KK.</td>
<td>Panel Space Heaters with Thermostat</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>LL.</td>
<td>Alarm Annunciator of each type</td>
<td>1 No.</td>
</tr>
<tr>
<td>MM.</td>
<td>Interpanel insulation barriers</td>
<td>20% Minimum 1 No</td>
</tr>
<tr>
<td>NN.</td>
<td>Maintenance Trolley for breaker of all rating</td>
<td>1 No.</td>
</tr>
<tr>
<td>OO.</td>
<td>Set of gaskets for all ratings &amp; type</td>
<td>1 Set</td>
</tr>
<tr>
<td>PP.</td>
<td>Panel shutter assembly</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>QQ.</td>
<td>Removable bus bar shrouds</td>
<td>1 Set</td>
</tr>
<tr>
<td>RR.</td>
<td>Bus bar mounted power fix contacts</td>
<td>1 Set</td>
</tr>
</tbody>
</table>

### 7.0 Each Bus Duct

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Bus support insulators each type</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>B.</td>
<td>Flexible connector (for switchgear end connection)</td>
<td>1 Set</td>
</tr>
<tr>
<td>C.</td>
<td>Flexible connector (for Transformer end connection)</td>
<td>1 Set</td>
</tr>
<tr>
<td>D.</td>
<td>Gasket</td>
<td>1 Set</td>
</tr>
<tr>
<td>E.</td>
<td>Bus duct CT’s / VT’s</td>
<td>1 Set</td>
</tr>
<tr>
<td>F.</td>
<td>Set of special tools, if necessary, for dismantling and maintenance</td>
<td>1 Set</td>
</tr>
</tbody>
</table>

### 8.0 HV Motor (For each rating)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Bearings housing (complete with End Shield) both Driving End and Non driving end</td>
<td>1 set</td>
</tr>
<tr>
<td>B.</td>
<td>Cooling fan</td>
<td>1 No.</td>
</tr>
<tr>
<td>C.</td>
<td>Space heater</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>D.</td>
<td>Terminal box</td>
<td>1 No.</td>
</tr>
<tr>
<td>E.</td>
<td>Terminal stud with bushing &amp; star links</td>
<td>2 sets</td>
</tr>
<tr>
<td>F.</td>
<td>RTDs for HV motors for Bearing/ hot air</td>
<td>2 Nos. each</td>
</tr>
<tr>
<td>G.</td>
<td>Dial Type thermometer</td>
<td>2 sets</td>
</tr>
<tr>
<td>H.</td>
<td>Grease nipple &amp; Plug (if installed)</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>I.</td>
<td>Charge of Lubricating oil (if not centrally lubricated)</td>
<td>1 Charge</td>
</tr>
</tbody>
</table>

### 9.0 LV Motor (For each rating)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Bearings housing (complete with End Shield) both Driving End and Non driving end</td>
<td>1 set</td>
</tr>
<tr>
<td>B.</td>
<td>Cooling fan</td>
<td>2 No.</td>
</tr>
<tr>
<td>C.</td>
<td>Terminal box</td>
<td>1 No.</td>
</tr>
<tr>
<td>D.</td>
<td>Terminal stud with bushing &amp; star links</td>
<td>1 No.</td>
</tr>
<tr>
<td>E.</td>
<td>Space heater, if installed</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>F.</td>
<td>Grease nipple &amp; Plug, if installed</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>G.</td>
<td>Cooling fan cover</td>
<td>1 No.</td>
</tr>
</tbody>
</table>

### 10.0 Interlocking switch socket & plug

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Switch of each rating</td>
<td>3 Nos.</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Quantity</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>B.</td>
<td>Fuse base of each rating</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>C.</td>
<td>Fuse of each rating</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>D.</td>
<td>Plug Top</td>
<td>3 Nos.</td>
</tr>
</tbody>
</table>

11.0 Lighting Fixtures

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>LED Lighting fixtures (along with Driver) alongwith LED Lamp</td>
<td>10% of the total no. of fixtures (Minimum of 5 No’s of each type)</td>
</tr>
<tr>
<td>B.</td>
<td>Terminal block of each type</td>
<td>5 Nos.</td>
</tr>
<tr>
<td>C.</td>
<td>Heat resistance toughened glass cover of each type</td>
<td>5 Nos.</td>
</tr>
<tr>
<td>D.</td>
<td>Fuse holder of each type</td>
<td>5 Nos.</td>
</tr>
<tr>
<td>E.</td>
<td>Fuse of each Type</td>
<td>5 Nos.</td>
</tr>
<tr>
<td>F.</td>
<td>Allen keys of different sizes as applicable</td>
<td>2 Sets</td>
</tr>
</tbody>
</table>

12.0 Battery Charger

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Set of diodes of each type and rating</td>
<td>2 Sets</td>
</tr>
<tr>
<td>B.</td>
<td>Set of silicon controlled Rectifiers</td>
<td>2 Sets</td>
</tr>
<tr>
<td>C.</td>
<td>Set of chokes of each type and rating</td>
<td>1 Set</td>
</tr>
<tr>
<td>D.</td>
<td>Set of resistors of each type and rating</td>
<td>1 Set</td>
</tr>
<tr>
<td>E.</td>
<td>Set of capacitors of each type and rating</td>
<td>1 Set</td>
</tr>
<tr>
<td>F.</td>
<td>Set of transistors of each type and rating</td>
<td>1 Set</td>
</tr>
<tr>
<td>G.</td>
<td>Set of load breaking switches of each type and rating</td>
<td>1 Set</td>
</tr>
<tr>
<td>H.</td>
<td>Off-Load Tap Changing Device</td>
<td>1 Set</td>
</tr>
<tr>
<td>I.</td>
<td>Current Regulator</td>
<td>1 Set</td>
</tr>
<tr>
<td>J.</td>
<td>Semiconductor fuses of each type and rating</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>K.</td>
<td>Set of contactors of each type and rating</td>
<td>2 Sets</td>
</tr>
<tr>
<td>L.</td>
<td>Set of thermal overload relays of each type and rating</td>
<td>2 Sets</td>
</tr>
<tr>
<td>M.</td>
<td>Set of auxiliary contactors of each type and rating</td>
<td>2 Sets</td>
</tr>
<tr>
<td>N.</td>
<td>Set of power contactors of each type and rating</td>
<td>2 Sets</td>
</tr>
<tr>
<td>O.</td>
<td>Set of control and selector switches of each type and rating</td>
<td>2 Sets</td>
</tr>
<tr>
<td>P.</td>
<td>Set of controller cards of each installed charger</td>
<td>2 Sets</td>
</tr>
<tr>
<td>Q.</td>
<td>Indicating lights of each colour &amp; voltage</td>
<td>2 Sets</td>
</tr>
<tr>
<td>R.</td>
<td>D.C. Ammeter</td>
<td>1 No.</td>
</tr>
<tr>
<td>S.</td>
<td>Miniature circuit Breaker of each type &amp; rating</td>
<td>1 No.</td>
</tr>
<tr>
<td>T.</td>
<td>PCB’s of each type</td>
<td>1 No.</td>
</tr>
<tr>
<td>U.</td>
<td>Float indicator</td>
<td>1 No.</td>
</tr>
<tr>
<td>V.</td>
<td>Thermometer</td>
<td>1 No.</td>
</tr>
<tr>
<td>W.</td>
<td>Under, over voltage and earth leakage protection devices</td>
<td>1 No.</td>
</tr>
<tr>
<td>X.</td>
<td>Panel / cabinet space heater</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>Y.</td>
<td>Thermostat</td>
<td>2 Nos.</td>
</tr>
</tbody>
</table>

13.0 Each Battery Bank

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Complete cells of each type</td>
<td>4 Sets</td>
</tr>
<tr>
<td>B.</td>
<td>Float guide</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>C.</td>
<td>Cell lid</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>D.</td>
<td>Level indicators</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>E.</td>
<td>Vent plugs</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>F.</td>
<td>Inter cell connectors with nuts, bolts and washers</td>
<td>2 Sets</td>
</tr>
<tr>
<td>G.</td>
<td>P.V.C. Spill Trays</td>
<td>2 Sets</td>
</tr>
<tr>
<td>H.</td>
<td>Terminal Post</td>
<td>2 Sets</td>
</tr>
</tbody>
</table>

### 14.0 Local Control Station

| A. | Trip – neutral – close switch | 20% |
| B. | Auto Manual / Local -Remote switch | 20% |
| C. | Ammeters of different ranges | 20% |
| D. | Terminal block | 20% |
| E. | Indicating Lamps of different type | 20% |
| F. | Push Buttons of different type | 20% |
| G. | Complete LCS of each type | 20% |

### 15.0 Junction Box

| A. | Junction Box of each type | 10 Nos. |

### 16.0 Electricals for Overhead Cranes & Hoists (per crane/hoist)

| A. | Bearings of each type & no. | 1 Set |
| B. | Contactor Coil of various ratings | 1 Set |
| C. | Complete set of contactor of each rating | 1 Set |
| D. | Limit switches of each type | 2 Nos. |
| E. | Push Button Elements | 20% |
| F. | Push Button Actuators | 20% |
| G. | Fuses of various ratings | 20% |
| H. | Fuse fittings of various ratings | 20% |
| I. | Indication lamp fittings of each type | 20% |
| J. | Overload relays of various ranges | 1 Set |
| K. | Brake coils for various brakes | 1 Set |
| L. | Set of carbon brushes in case of S.R. motors | 1 Set |
| M. | Set of resistors for S.R. motors | 1 Set |
| N. | Any special tools and tackles required for maintenance | 1 Set |

### 17.0 Variable Frequency Drives

| A. | Complete unit of each type | 1 No. |
| B. | Set of fuses of all types & sizes used in system | 5 Sets |
| C. | Software for parameter setting each type | 1 Set |

### 18.0 Fire Alarm & Detection System

<p>| A. | Detectors of each type | 20% |</p>
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.</td>
<td>Loop card of each type</td>
<td>10%</td>
</tr>
<tr>
<td>C.</td>
<td>Charger card</td>
<td>10%</td>
</tr>
<tr>
<td>D.</td>
<td>Interface Units of each type</td>
<td>10%</td>
</tr>
<tr>
<td>E.</td>
<td>Power supply unit of each type</td>
<td>10%</td>
</tr>
<tr>
<td>F.</td>
<td>PCB of all types</td>
<td>20%</td>
</tr>
<tr>
<td>G.</td>
<td>Manual Call Points</td>
<td>10%</td>
</tr>
<tr>
<td>H.</td>
<td>Fuses of each type &amp; rating</td>
<td>10%</td>
</tr>
<tr>
<td>I.</td>
<td>Control relays of each type</td>
<td>10%</td>
</tr>
<tr>
<td>J.</td>
<td>Audible hooter/buzzer</td>
<td>10%</td>
</tr>
</tbody>
</table>

### 19.0 Capacitor Bank

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Capacitor Unit of each rating</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>B.</td>
<td>Fuses (if used) of each rating</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>C.</td>
<td>Power Contactor of each rating</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>D.</td>
<td>PF controller card/unit of each type</td>
<td>1 No.</td>
</tr>
<tr>
<td>E.</td>
<td>Limit Switch for Capacitor Bank of each type</td>
<td>3 Nos.</td>
</tr>
</tbody>
</table>

### 20.0 Cathodic Protection

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Anode</td>
<td>2 Nos.</td>
</tr>
<tr>
<td>B.</td>
<td>Transformer/rectifier unit (complete)</td>
<td>1 No.</td>
</tr>
<tr>
<td>C.</td>
<td>Half cells</td>
<td>5 No’s</td>
</tr>
<tr>
<td>D.</td>
<td>For Transformer Rectifier Unit</td>
<td></td>
</tr>
<tr>
<td>E.</td>
<td>D.C Voltmeter</td>
<td>1 No.</td>
</tr>
<tr>
<td>F.</td>
<td>D.C Ammeter</td>
<td>1 No.</td>
</tr>
<tr>
<td>G.</td>
<td>A.C Voltmeter</td>
<td>1 No.</td>
</tr>
<tr>
<td>H.</td>
<td>A.C Ammeter</td>
<td>1 No.</td>
</tr>
<tr>
<td>I.</td>
<td>Corrosion voltmeter</td>
<td>1 No.</td>
</tr>
<tr>
<td>J.</td>
<td>Diodes</td>
<td>1 Set</td>
</tr>
<tr>
<td>K.</td>
<td>SCRs</td>
<td>1 Set</td>
</tr>
<tr>
<td>L.</td>
<td>D.C. Fuses for output side</td>
<td>1 Set</td>
</tr>
<tr>
<td>M.</td>
<td>HRC fuses for Diodes</td>
<td>1 Set</td>
</tr>
<tr>
<td>N.</td>
<td>A.C fuses for input side</td>
<td>1 Set</td>
</tr>
<tr>
<td>O.</td>
<td>D.C lighting arrestor</td>
<td>1 No.</td>
</tr>
<tr>
<td>P.</td>
<td>MCB of each rating</td>
<td>1 No.</td>
</tr>
<tr>
<td>Q.</td>
<td>Electronic Control Cards each type</td>
<td>1 No.</td>
</tr>
<tr>
<td>R.</td>
<td>Filter Circuit Capacitor</td>
<td>1 No.</td>
</tr>
<tr>
<td>S.</td>
<td>Signal Light assembly for annunciation</td>
<td>1 No.</td>
</tr>
<tr>
<td>T.</td>
<td>R.C. Surge Diverter</td>
<td>1 No.</td>
</tr>
<tr>
<td>U.</td>
<td>Control transformer</td>
<td>1 No.</td>
</tr>
<tr>
<td>V.</td>
<td>Coarse &amp; Fine Control Switch</td>
<td>1 No.</td>
</tr>
<tr>
<td>W.</td>
<td>Auto Manual Mode Selector Switch</td>
<td>1 No.</td>
</tr>
<tr>
<td>X.</td>
<td>Toggle Switches</td>
<td>2 Nos.</td>
</tr>
</tbody>
</table>

### 21.0 Each ANNUNCIATOR PANEL

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Hooters</td>
<td>1 No.</td>
</tr>
</tbody>
</table>
## SPARE LIST

### B. Push Buttons of each type
- 3 Sets

### C. Terminals
- 3 Nos.

### D. Acrylics
- 1 No.

### E. PCB card of each type
- 1 No.

### F. LED of each colour & voltage
- 3 Sets

### G. DIP Switches
- 3 Nos.

### H. CPU
- 1 No.

### I. SMPS
- 1 No.

### J. Relays of each type
- 20%

#### 23.0 DG Set of each rating
(DG power board spares shall be as per switchgear spares)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>O Ring of various types &amp; sizes</td>
<td>1 Set</td>
</tr>
<tr>
<td>B</td>
<td>Bearing of various types &amp; sizes</td>
<td>1 Set</td>
</tr>
<tr>
<td>C</td>
<td>Gaskets of various types &amp; sizes</td>
<td>1 Set</td>
</tr>
<tr>
<td>D</td>
<td>Lube oil filter, air filters etc.</td>
<td>1 Set each</td>
</tr>
<tr>
<td>E</td>
<td>Solenoids of various types &amp; sizes</td>
<td>1 No.</td>
</tr>
<tr>
<td>F</td>
<td>Electrical actuator of various types &amp; sizes</td>
<td>1 No.</td>
</tr>
<tr>
<td>G</td>
<td>Circuit breaker arcing &amp; fixed contact assembly</td>
<td>1 No.</td>
</tr>
<tr>
<td>H</td>
<td>Excitations system diodes</td>
<td>1 Set</td>
</tr>
<tr>
<td>I</td>
<td>Fuses of all ratings</td>
<td>1 No.</td>
</tr>
<tr>
<td>J</td>
<td>AVR Protection relays</td>
<td>1 No.</td>
</tr>
<tr>
<td>K</td>
<td>Instrumentation items like pressure/temp switches, gauges etc.</td>
<td>1 No. Each</td>
</tr>
<tr>
<td>L</td>
<td>Battery cells for protection and control supplies</td>
<td>1 No.</td>
</tr>
<tr>
<td>M</td>
<td>PLC Spares for logic and monitoring</td>
<td>1 Set of each type</td>
</tr>
<tr>
<td>N</td>
<td>Any other spare part not covered but required</td>
<td>1 No.</td>
</tr>
</tbody>
</table>

#### 25.0 NIFPS

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Fitted nitrogen cylinder</td>
<td>1 No.</td>
</tr>
<tr>
<td>B</td>
<td>Fire detectors of each type</td>
<td>3 Nos.</td>
</tr>
<tr>
<td>C</td>
<td>Heat sensor assembly of each type</td>
<td>1 Set</td>
</tr>
<tr>
<td>D</td>
<td>PNRBV of each type</td>
<td>1 Set</td>
</tr>
<tr>
<td>E</td>
<td>Limit switch for fire detector of each type</td>
<td>2 Sets</td>
</tr>
<tr>
<td>F</td>
<td>Thermostat of each type</td>
<td>2 Sets</td>
</tr>
<tr>
<td>G</td>
<td>Heating element of each type</td>
<td>2 Sets</td>
</tr>
<tr>
<td>H</td>
<td>Fire survival cable sufficient for one system</td>
<td>1 Set</td>
</tr>
</tbody>
</table>

1) Set means complete replacement of particular part in one machine.
2) Wherever "Each Type" is specified, it means "of the Type/make/model/size/rating and exactly replaceable"
3) Wherever "% qty." is specified, Bidder to quote in next higher rounded figure
4) Out of % age spares and minimum qty specified against each item - higher of the two shall be supplied.
5) Electrical EQUIPMENT which has not been mentioned in this table and needs spare parts, CONTRACTOR shall consider spare parts for them, the quantities for such spare parts shall then be APPROVED by OWNER/CONSULTANT.
2.15 **Instrumentation Items:**

1) Set means complete replacement of particular part in one machine.
2) Wherever “Each Type” is specified, it means “of the Type/make/model/size/rating and exactly replaceable”
3) Wherever “% qty.” is specified, Bidder to quote in next higher rounded figure
4) Out of % age spares and minimum qty specified against each item - higher of the two shall be supplied.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Field instruments</td>
<td>10% of each type of instruments, subject to minimum 2 nos. of each type</td>
</tr>
<tr>
<td></td>
<td>Pressure Gauges, Differential Pressure Gauge, Draft Gauges, Field Indicators, RTD/T/C with Thermowells, welded thermowell, Skin Thermocouple Sets, Speed Probes with Cables and Fixing Screws and Bolts, Vibration Probes, with Cables (including extension cable) and Fixing Screws and Bolts, Speed Transmitter with Cables and Fixing Screws and Bolts, Proximeters of diff. model and Fixing Screws and Bolts, Gas Sensors with Cables and Fixing Screws and Bolts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pressure Switches, DP Switches, Purge Rotameters</td>
<td>10% of each type of instruments, subject to minimum 2 nos of each type</td>
</tr>
<tr>
<td></td>
<td>Special thermocouples ( like reactors) /multipoint thermocouples,</td>
<td>10% of each length subject to minimum 1 number of each type.</td>
</tr>
<tr>
<td></td>
<td>Skin Type Thermocouple-</td>
<td>10% of total subject to minimum 1 number Complete Set of each type.</td>
</tr>
<tr>
<td></td>
<td>Float and micro switch assembly for level switch</td>
<td>10% of each length subject to minimum 1 number of each type.</td>
</tr>
<tr>
<td></td>
<td>Transmitters for Flow, Pressure, Temperature, Level, Diff. Pressure application, Remote Seal Transmitter, Transmitter for LEL/GAS Detector System including Sensors .</td>
<td>10% of each type of instruments, subject to minimum 2 nos of each type</td>
</tr>
<tr>
<td></td>
<td>Hydra Step</td>
<td>1 no. Electronic unit or 10% subject to minimum. 20% or Min 3 Nos of Sensor Probes</td>
</tr>
</tbody>
</table>
|         | Mass flow meter & Mag Flow meter | A) Power fuses 6 nos per set  
B) Sensor assembly-10% min 1 no  
C) 10% or minimum one number complete electronic head unit |
|         | Vortex Flow Meter | A) One sensing probe ,one set of gasket and Packing for each type and Size  
B) 10% or minimum one number complete electronic head unit |
|         | Ultrasonic Flow meter | A) 1 pair probe for each instrument  
B) 1 number electronic card of each |
<table>
<thead>
<tr>
<th>Item Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass tube Rota meters</td>
<td>20% or min 2 Nos of glass tubes of each size/rating /make.</td>
</tr>
<tr>
<td>Variable Flow meter (Rota meters)</td>
<td>10% or minimum one no. float &amp; set of Packing for each type, size, rating and material</td>
</tr>
<tr>
<td>Averaging Pitot Tube</td>
<td>Set of Gasket, O-ring, Packing for Retract Mechanism and one no. Needle Valve with each Pitot Tube.</td>
</tr>
</tbody>
</table>
| Flame scanners and optical pyrometer                                              | a)10% subject to minimum 1 No. of each type.  
b)As required for 1 year operation or Min 2 Nos Complete flame scanner |
| 2.0 Displacer type Level Transmitters                                            | A) 10% of each type of instruments head with Torque Tube Assembly and Transmitter, subject to minimum 2 nos of each type. 1 No of float of each type.  
B) 10% Electronic cards and Display module – Minimum 1 no. of each type |
| 2.1a Ultrasonic / Guided Wave Radar Type – Level Instrument                      | A) 10% complete Instrument – Minimum 1 No. of each Type / Range / Material  
B) 10% Electronic – module / Cards /Display module – Minimum 1 no. of each type |
<p>| 2.2 Level gauge- Transparent / Reflex Type                                       | 20% subject to minimum 10 numbers of glass along with pair of Gaskets and glands sets for l/V valves of each type, size (Cushion &amp; Wet Gaskets), whichever is higher. |
| 2.2.1 Level Gauge- Magnetic Type                                                 | 10% subject to minimum 1 set of Float, Magnet/ball follower-ring gaskets of each type. |
| 3.0 Control Valve, Shut Down, On-Off, Butterfly, Ball Valves, Gate Valves, Angle Valves, PCV, MOV, Safety Valve Spares | 20% of each type of instruments, subject to minimum 1 no. of each type |
| 3.1 Soft part / actuator spares, including actuator diaphragm, actuator seal kit and spring sets, for each type of actuator | Trim set consisting of seat ring / seal ring, plug with stem, cage (wherever applicable), packing material for each make, type , size, 23 reassure rating valve to be provided as spare |
| 3.2 Trim Set                                                                    | one complete Actuator for each type and size |
| 3.3 Complete Actuator with Hand Wheel assembly                                   |          |</p>
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Quantity/Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4</td>
<td>Complete Spare Control Valve for Antisurge Control Valve</td>
<td>One No</td>
</tr>
<tr>
<td>3.5</td>
<td>Gland packing, O rings, Packing and Bonnet gasket, seat gasket</td>
<td>100% for each valve. i.e. one set for each tag.</td>
</tr>
<tr>
<td>3.6</td>
<td>Greases and grease guns</td>
<td>5 sets of each type of grease and 1 grease gun of each type</td>
</tr>
<tr>
<td>3.7</td>
<td>Solenoid valves</td>
<td>10% of each type of instruments, subject to minimum 2 nos of each type</td>
</tr>
<tr>
<td>3.8</td>
<td>Proximity switches including enclosure</td>
<td>10% of each type of instruments, including enclosure - subject to minimum 2 nos of each type</td>
</tr>
<tr>
<td>3.9</td>
<td>SMART Positioners</td>
<td>10% of each type of instruments, subject to minimum 2 nos of each type</td>
</tr>
<tr>
<td>3.11</td>
<td>Other accessories: Quick Exhaust relay, Volume Boosters, Air Filter regulators, position Transmitters, change over relay, NRV, Pilot valves.</td>
<td>10% of each type of instruments, subject to minimum 3 nos of each type. Air filter regulator shall be minimum 20%.</td>
</tr>
<tr>
<td>3.12</td>
<td>PRDS &amp; De-super heater unit</td>
<td>a) Same as those of Control Valves</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Gaskets for valve and connections per unit (if such gaskets, are special and supplied by PRDS/De-Super heater vendor)</td>
</tr>
<tr>
<td>3.13</td>
<td>For PCV Repair kit consisting of (orifice, plug, spring, gasket, diaphragm, spring, O-ring for each valve.</td>
<td>20% or minimum 1 no. in each type</td>
</tr>
<tr>
<td>3.14</td>
<td>HHT loaded with latest HART configurator software (Emerson make)</td>
<td>1 no. minimum</td>
</tr>
<tr>
<td>3.15</td>
<td>Safety Valve:</td>
<td>Set of each type/ size. 1 Set comprising of 1 upper adjusting ring, 1 lower adjusting ring, 1 disk, 1 Nozzle, 1 stem &amp; 1 Gasket set</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20% of each size and rating of Discs, Nozzles, bellows, springs etc. Additionally Minimum 2 Nos of Complete PSV for critical application (Very high pressure PSV's e.g. Boiler drum application etc.)</td>
</tr>
<tr>
<td>4.0</td>
<td>DCS, ESD, F&amp;G PLC, Storage PLC, Analyser PLC, Any other Control and PLC system.</td>
<td></td>
</tr>
<tr>
<td>4.1</td>
<td>CPU</td>
<td>10% or minimum 1 no. each type.</td>
</tr>
<tr>
<td>4.1a</td>
<td>Communication cards, Processor cards (Controller), FTA cards</td>
<td>2 nos of each type of cards.</td>
</tr>
<tr>
<td>4.2</td>
<td>System Pre-fab cables, I/O Card cables, communication bus cables.</td>
<td>10% or min. 5 sets of each type with all connectors, plugs.</td>
</tr>
<tr>
<td>4.3</td>
<td>Racks, Backplane units</td>
<td>2 Nos each type</td>
</tr>
<tr>
<td>4.4</td>
<td>Local Panel, Hardwire console &amp; annunciator</td>
<td>10% or minimum 2 no. each type.</td>
</tr>
<tr>
<td>No.</td>
<td>Item Description</td>
<td>Quantity/Information</td>
</tr>
<tr>
<td>------</td>
<td>----------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4.5</td>
<td>HDD unit</td>
<td>2 set of each type (normal as well as Raid-5) with all connectors, plugs.</td>
</tr>
<tr>
<td>4.6</td>
<td>Various Keyboards (including operator keyboard) /mouse</td>
<td>2 nos. of keyboard each type and 5 Nos. of mouse.</td>
</tr>
<tr>
<td>4.7</td>
<td>Relays</td>
<td>5% of each type of relays, including relevant terminal modules/sockets minimum 5 nos. of each type</td>
</tr>
<tr>
<td>4.8</td>
<td>Pushbuttons, Lamps, Selector switches</td>
<td>10% of each type, including relevant terminal modules/accessories as a complete set</td>
</tr>
<tr>
<td>4.10</td>
<td>All type of system/PDB/Marshalling cabinet /console filters</td>
<td>100%</td>
</tr>
<tr>
<td>4.11</td>
<td>All type of system/PDB/Marshalling cabinet/console fan</td>
<td>2 Nos of each type including relevant terminal modules/pre-fab system cables.</td>
</tr>
<tr>
<td>4.12</td>
<td>All type of system/PDB/Marshalling cabinet/console Tube light</td>
<td>2 Nos of each type.</td>
</tr>
<tr>
<td>4.13</td>
<td>All type of various PDBs Voltmeters</td>
<td>2 Nos of each type.</td>
</tr>
<tr>
<td>4.14</td>
<td>I/O Cards</td>
<td>20% of each type of card, including relevant terminal modules/pre-fab system cables, etc., subject to minimum of 5 nos. each</td>
</tr>
<tr>
<td>4.15</td>
<td>Various System Battery, Terminators</td>
<td>1 no. of each type</td>
</tr>
<tr>
<td>4.16</td>
<td>All system Fuses and various glass fuses</td>
<td>100% for imported fuses</td>
</tr>
<tr>
<td>4.17</td>
<td>All PDB fuses, like HRC, GSA Fuses</td>
<td>100% of total qty. of each type</td>
</tr>
<tr>
<td>4.18</td>
<td>MCBs</td>
<td>5 Nos. of each type</td>
</tr>
<tr>
<td>4.19</td>
<td>Terminal Blocks</td>
<td>Spare Terminal Blocks along with DIN rail – 100 nos each type</td>
</tr>
<tr>
<td>4.20a</td>
<td>Cables for wiring inside Marshalling Racks of DCS of relevant size</td>
<td>100 mtr of each color and size</td>
</tr>
<tr>
<td>4.20b</td>
<td>Cables for wiring inside Marshalling Racks of ESD of relevant size</td>
<td>100 mtr of each color and size</td>
</tr>
<tr>
<td>4.21</td>
<td>24 V DC Bulk Power Supply modules</td>
<td>Min. 2 nos of each type</td>
</tr>
<tr>
<td>4.22</td>
<td>System DC Power supply for DCS</td>
<td>Min. 2 nos of each type</td>
</tr>
<tr>
<td>4.23</td>
<td>System DC Power supply for ESD</td>
<td>Min. 2 nos of each type</td>
</tr>
<tr>
<td>4.23a</td>
<td>Diode-o ring modules</td>
<td>10% or minimum 1 no. each type.</td>
</tr>
<tr>
<td>4.24</td>
<td>Safety barriers, active isolators, signal convertors, trip amplifiers, signal multipliers</td>
<td>10% of each type of instruments, subject to minimum 5 nos of each type</td>
</tr>
<tr>
<td>4.25</td>
<td>Hubs, Bus units, Switches, Routers</td>
<td>20% or Min 1 nos of each type</td>
</tr>
<tr>
<td>4.26</td>
<td>OPC / Modbus interface Cards</td>
<td>1 No each along with connectors / cables</td>
</tr>
<tr>
<td>4.27</td>
<td>DCS operator and engineering subsystem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Communication card Operator Station communication bus</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>Communication card for Engineering Station communication bus</td>
<td>1 No.</td>
</tr>
<tr>
<td></td>
<td>Motherboard for Operator Workstation</td>
<td>1 No.</td>
</tr>
<tr>
<td>Motherboard for Engineering Workstation</td>
<td>1 No.</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>SMPS</td>
<td>1 No.</td>
<td></td>
</tr>
<tr>
<td><strong>4.28</strong> PLC operator and engineering subsystem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication card for PLC programming Station communication bus</td>
<td>1 No.</td>
<td></td>
</tr>
<tr>
<td>Communication card for PLC SOE Station communication bus</td>
<td>1 No.</td>
<td></td>
</tr>
<tr>
<td>Communication card for PLC Operating Station communication bus</td>
<td>1 No.</td>
<td></td>
</tr>
<tr>
<td><strong>5.0 Special control system modules</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) WoodWard Digital Governor,</td>
<td>1 no. of each (Controller, IOs ,cables, barriers Complete unit).</td>
<td></td>
</tr>
<tr>
<td>b) WoodWard PROTECH 2003/Braun Speed Trip unit, Speed Probes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Any other Control system module associated with Speed trip and Monitoring system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) Voith Make E/H Converters.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6.0 Bentley Nevada 3500 Series Vibration Monitoring System Spares</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1 Central Rack cards : Power supply card, Vibration/Thrust Monitoring card, Axial displacement card, Speed monitor card, Key phasor module, Relay module, Display Unit., transducers and transmitters</td>
<td>20% of each type of cards, subject to minimum 2 nos of each type</td>
<td></td>
</tr>
<tr>
<td>6.2 Vibration probes with leads, axial displacement probes with leads, Bearing thermo elements, speed probes with leads, I/H converter, E/H Converter, trip solenoid valves, transducers, barriers for vibration probes/ Proximeter.</td>
<td>10% or minimum 1 no. of each type. Proximeter 20%</td>
<td></td>
</tr>
<tr>
<td><strong>7.0 Consumables for DCS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.1 Printer papers A3, A4 size</td>
<td>A3- 10 Rims, A4- 50 Rims</td>
<td></td>
</tr>
<tr>
<td>7.2 Laser Cartridges (Black and Color)</td>
<td>For 6 month usage, min. 2 sets for each printer</td>
<td></td>
</tr>
<tr>
<td>7.3 DATs of HP/ 3-M</td>
<td>25 nos. each</td>
<td></td>
</tr>
<tr>
<td>7.4 CDs of HP/Samsung</td>
<td>200 with individual casing</td>
<td></td>
</tr>
<tr>
<td>7.5 DVDs of HP/Samsung</td>
<td>200 with individual casing</td>
<td></td>
</tr>
<tr>
<td><strong>8.0 GC Spares</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a Set of Filters</td>
<td>1 set</td>
<td></td>
</tr>
<tr>
<td>b Detector Assembly</td>
<td>1 set</td>
<td></td>
</tr>
<tr>
<td>c PCB assembly Power Supply</td>
<td>2 nos.</td>
<td></td>
</tr>
<tr>
<td>d PCB assembly Digital temp control</td>
<td>2 nos each type</td>
<td></td>
</tr>
<tr>
<td>e Pressure Regulator</td>
<td>1 no</td>
<td></td>
</tr>
<tr>
<td>f Thermocouple Assembly</td>
<td>1 no</td>
<td></td>
</tr>
<tr>
<td>g Sol Valve</td>
<td>1 no</td>
<td></td>
</tr>
<tr>
<td>h Backplane Assembly</td>
<td>1 no</td>
<td></td>
</tr>
<tr>
<td>i PCB Assembly</td>
<td>1 no</td>
<td></td>
</tr>
<tr>
<td>j Ignitor Assembly</td>
<td>1 no</td>
<td></td>
</tr>
<tr>
<td>k Pressure Sensor</td>
<td>1 no</td>
<td></td>
</tr>
<tr>
<td>l Filament Kit</td>
<td>2 nos</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>m</td>
<td>Set of Fuses</td>
<td>1 no</td>
</tr>
<tr>
<td>n</td>
<td>Set of Fittings</td>
<td>1 no</td>
</tr>
<tr>
<td>o</td>
<td>Pressure Gauge</td>
<td>1 no</td>
</tr>
<tr>
<td>p</td>
<td>Temperature gauge</td>
<td>1 no</td>
</tr>
<tr>
<td>q</td>
<td>Sample flow meter</td>
<td>1 no</td>
</tr>
<tr>
<td>r</td>
<td>Bypass flow meter</td>
<td>1 no</td>
</tr>
</tbody>
</table>

**9.0 Gas Analyzer Spares applicable for all Gas Analyzers / MassSpectrometer**

| a | Sample Flow Meter | 1 no |
| b | By pass Flow meter | 1 no |
| c | Solenoid Valve | 1 no |
| d | Communication board | 1 no of each type |
| e | Display Unit | 1 no each type |
| f | CPU Board | 1 no each type |
| g | Sensor Electronic | 1 no each type |
| h | Modulation Unit | 1 no each type |
| i | Sample Cell | 1 no |
| j | Sensor | 1 no each type |
| k | O Ring | 3 sets |
| l | Thermal fuses | 2 sets |
| m | Heating cartridge | 1 set |
| n | Thermal trip | 2 set |
| o | Analogue module | 1 set each type |
| p | Filter membrane (pack of 25) | 1 set |
| q | Fuse | 1 set each type |

**10.0 pH / Conductivity Analyzer**

| a | 2 (Two) Complete Analyzer complete with sensor, cables, transmitters etc of each type |

**11.0 Silica Analyzer/Sodium/chlorine/ moisture /Turbidity /density/O2/CO/NOx/SPM Spares**

| a | Sensor board | 1 no |
| b | Sensor and Detector | 1 no each type |
| c | Rotameter ( if applicable) | 1 no |
| d | Pressure Control Valve ( if applicable) | 1 no |
| e | Fuses | 5. sets. |
| f | Electronic card | 1 no each type |
| g | Other Aux. Cards | 1 each |
| h | Probe | 1 no each type |
| i | Filters, O-rings, Gaskets | 2 sets |
| j | Consumable Kit | 2 sets |

**12.0 Sample Conditioning system applicable for all analyzers / Mass spectrometer**

<p>| a | Complete sample kit for sample pumps inclusive of ‘O’ rings, Seal ring, Diaphragm | 1 set |
| b | Solenoid valve for, more than one stream application | 1 no |
| c | Flow switch | 1 no |
| d | Vaporization system if required, which includes vaporizer, | 1 set |</p>
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>e</td>
<td>Thermostat, electrical tracing cable and heater</td>
</tr>
<tr>
<td>f</td>
<td>Cooling system if required, which includes one cooler, flow conditioning system</td>
</tr>
<tr>
<td>g</td>
<td>Sample handling system fitting, valves, pressure gauges, regulators, solenoid valves, flow meters / flow switches and other components, etc</td>
</tr>
<tr>
<td>g</td>
<td>Consumables like filters, membranes, reagents, cal. Gas, carriers</td>
</tr>
<tr>
<td>13.0</td>
<td>Flame Scanner</td>
</tr>
<tr>
<td>14.0</td>
<td>Ferruling machine</td>
</tr>
<tr>
<td>15.0</td>
<td>Snubber, Syphon, Gauge Saver</td>
</tr>
<tr>
<td>16.0</td>
<td>Loop powered indicators</td>
</tr>
<tr>
<td>17.0</td>
<td>Panel mounted instruments</td>
</tr>
<tr>
<td>25.0</td>
<td>Tools</td>
</tr>
<tr>
<td>25.1</td>
<td>Technician's Tool Kit Set including screw drivers, slide wrench, O &amp; D Spanners Kits</td>
</tr>
<tr>
<td>25.2</td>
<td>Crimping Tool for RJ-45 Connector, Tapria</td>
</tr>
<tr>
<td>25.3</td>
<td>Crimping Tool 0.5 to 4.0 mm2 wire, Tapria</td>
</tr>
<tr>
<td>25.4</td>
<td>Crimping Tool BNC connector for Bentely Neveda</td>
</tr>
<tr>
<td>25.5</td>
<td>Torque Wrench (Adjustable)</td>
</tr>
<tr>
<td>25.6</td>
<td>Insulation Remover</td>
</tr>
<tr>
<td>25.7</td>
<td>IC Puller</td>
</tr>
<tr>
<td>25.8</td>
<td>Logic probe</td>
</tr>
<tr>
<td>25.9</td>
<td>Screw driver kit (Taparia make)</td>
</tr>
<tr>
<td>25.10</td>
<td>Allen Key Set (1 mm to 8 mm)</td>
</tr>
<tr>
<td>25.11</td>
<td>Lamp puller</td>
</tr>
<tr>
<td>25.12</td>
<td>Torches (LED) handheld</td>
</tr>
<tr>
<td>25.13</td>
<td>Torches (Head Lamp)</td>
</tr>
<tr>
<td>25.14</td>
<td>Battery charger along with 1 set of batteries</td>
</tr>
<tr>
<td>26.0</td>
<td>CCTV camera, camera station, lens with zoom, Pan &amp; Tilt Unit, Receiver Unit, electronic unit, power supply, etc.</td>
</tr>
<tr>
<td>27.0</td>
<td>EPABX Unit, Electronic Card each type</td>
</tr>
<tr>
<td>28.0</td>
<td>Gas Detector system</td>
</tr>
<tr>
<td>28.1</td>
<td>Transmitter assembly (including field display)</td>
</tr>
<tr>
<td>28.2</td>
<td>Sensors</td>
</tr>
<tr>
<td>29.0</td>
<td>Smoke Detectors, MCP, Sounders, Hooters</td>
</tr>
</tbody>
</table>
30.0 Pressure Relief Valves/Thermal Relief Valves / Vacuum Relief Valves / Low Pressure Relief Valves / Pilot Operated Valves  
10% of minimum one of each type & size for nozzle, disc insert, guide whichever is higher

30.0a Rupture Disc  
2 spare disc for each Tag.

31.0 MOVs  
Main PCB of each type 
Local / Remote / off Selector Switch each type 
Open / close / stop Selector Switch each type  
1 Nos  
1 Nos  
1 Nos

31.0 Installation Material

31.1 Instrument valves and  
10% subject to minimum 1 no. of each type.

31.1.1 Valve manifolds  
10% subject to minimum 3 no. of each type.

31.2 Tube fittings  
10% subject to minimum 10 no. of each type.

31.3 Tubes  
10% of the total length of each type

31.4 Cables  
10% of the total length of each type

31.5 Junction boxes and cable glands  
10% subject to minimum 1 no. of each type

2.16 Material Handling items

Coal & ash Handling items:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Description</th>
<th>Quantity (Minimum one no. to be provided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Conveyor system</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Pulleys complete with shaft excluding bearing &amp; plummer blocks (complete with lagging)</td>
<td>1 no. of each type and size in pulley drum and shaft dia. (for population up to 10 Nos)</td>
</tr>
<tr>
<td>2.</td>
<td>Plummer Block complete with bearings &amp; sleeves</td>
<td>2 no. each type and size</td>
</tr>
<tr>
<td>3.</td>
<td>a. Roller each type &amp; size (Carrying, Return, self-aligning etc)</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>b. Roller each type &amp; size (impact)</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>c. Roller Brackets with bolts (each type &amp; size)</td>
<td>20%</td>
</tr>
<tr>
<td>4.</td>
<td>a. Idlers set (Carrying, Return)</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>b. Idlers set (impact)</td>
<td>40%</td>
</tr>
<tr>
<td>B.</td>
<td>Conveyor Belting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Main Conveyors</td>
<td>one drum length of 250m of each type, size and rating</td>
</tr>
<tr>
<td></td>
<td>Boom conveyor, belt feeder, intermediate conveyor &amp; bunker seal belt</td>
<td>one complete length of each</td>
</tr>
<tr>
<td>C</td>
<td>Gear Box (items for which, gear box spares are not mentioned specifically)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Input shafts with pinion</td>
<td>1 set of each type and rating</td>
</tr>
<tr>
<td>Item</td>
<td>Quantity</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>---------------------------</td>
<td></td>
</tr>
<tr>
<td>Oil seals</td>
<td>2 sets of each type and rating</td>
<td></td>
</tr>
<tr>
<td>Bearings</td>
<td>1 set of each type and rating</td>
<td></td>
</tr>
<tr>
<td>Hold back device</td>
<td>2 nos. of each type and rating</td>
<td></td>
</tr>
<tr>
<td>Cooling fan with cover</td>
<td>2 nos. of each type and rating</td>
<td></td>
</tr>
<tr>
<td>Complete gear box assy with hold back device</td>
<td>1 set of each type and rating</td>
<td></td>
</tr>
<tr>
<td><strong>D Coupling</strong> (items for which, coupling spares are not mentioned specifically)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>a) Gear coupling</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gear Coupling</td>
<td>2 nos of each type</td>
<td></td>
</tr>
<tr>
<td>Bolts for gear coupling</td>
<td>2 sets of each size</td>
<td></td>
</tr>
<tr>
<td>Seal kit for gear coupling (o-ring)</td>
<td>2 sets of each type</td>
<td></td>
</tr>
<tr>
<td><strong>b) Fluid Coupling</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluid Coupling complete</td>
<td>1 no. of each type and size</td>
<td></td>
</tr>
<tr>
<td>Multi Disc assembly (for fluid coupling), if applicable</td>
<td>4 nos each type and size</td>
<td></td>
</tr>
<tr>
<td>Resilient Drive plate assy., if applicable</td>
<td>1 no. of each type and size</td>
<td></td>
</tr>
<tr>
<td>Bearings</td>
<td>1 no. of each type and size</td>
<td></td>
</tr>
<tr>
<td>Seal kit for fluid coupling</td>
<td>2 sets of each size</td>
<td></td>
</tr>
<tr>
<td>Fusible plug</td>
<td>10 nos. Of each size</td>
<td></td>
</tr>
<tr>
<td>Complete actuator and engaging assembly (including motor, gear box etc.)</td>
<td>1 set of each type</td>
<td></td>
</tr>
<tr>
<td>Oil Cooler assembly (if applicable)</td>
<td>1 set of each type</td>
<td></td>
</tr>
<tr>
<td>Oil pump-motor set (if applicable)</td>
<td>1 set of each type</td>
<td></td>
</tr>
<tr>
<td>Water pump motor</td>
<td>1 set of each type</td>
<td></td>
</tr>
<tr>
<td>Oil filters</td>
<td>5 sets of each type</td>
<td></td>
</tr>
<tr>
<td>Oil Cooler valves (if applicable)</td>
<td>2 nos. of each type</td>
<td></td>
</tr>
<tr>
<td><strong>E. Brakes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brakes</td>
<td>1 no of each size &amp; type</td>
<td></td>
</tr>
<tr>
<td>Brake shoes</td>
<td>2 sets of each size</td>
<td></td>
</tr>
<tr>
<td><strong>F. Pulleys</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulleys complete with shaft excluding bearing &amp; Plummer blocks (complete with lagging)</td>
<td>1 no. of each type and size in pulley drum and shaft dia.(for population upto 10 Nos)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 no. of each type and size in pulley drum and shaft dia.(for population more than 10 Nos)</td>
<td></td>
</tr>
<tr>
<td>Plummer Block complete with bearings &amp; sleeves</td>
<td>2 nos. each type and size</td>
<td></td>
</tr>
<tr>
<td>SS Pulleys complete with shaft excluding bearing &amp;plummer blocks (complete with lagging)</td>
<td>1 no. of each type and size in pulley drum and shaft dia.</td>
<td></td>
</tr>
</tbody>
</table>
### G. Belt cleaners and skirt board

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modular segments for belt cleaner</td>
<td>5 % of total population of each type &amp; size</td>
<td></td>
</tr>
<tr>
<td>Modular segments for skirt board</td>
<td>5 % of total population of each type &amp; size</td>
<td></td>
</tr>
<tr>
<td>Skirt Rubber</td>
<td>5 % of total population of each type &amp; size</td>
<td></td>
</tr>
<tr>
<td>Complete belt cleaner (internal / external)</td>
<td>2 % of total population of each type &amp; size</td>
<td></td>
</tr>
</tbody>
</table>

### H. In-line magnetic separators

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleated conveyor belt</td>
<td>1 set</td>
<td></td>
</tr>
<tr>
<td>Motor, gear box drive assy. complete</td>
<td>1 set</td>
<td></td>
</tr>
<tr>
<td>Pulleys with plummer block &amp; bearings</td>
<td>1 set of each size &amp; type</td>
<td></td>
</tr>
</tbody>
</table>

### I. Coal crusher

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plummer Block assembly complete including bearing, lock nut, lock washer etc.</td>
<td>2 Set</td>
<td></td>
</tr>
<tr>
<td>Shaft seal</td>
<td>4 Sets</td>
<td></td>
</tr>
<tr>
<td>Hammer sets</td>
<td>2 sets for each crusher</td>
<td></td>
</tr>
<tr>
<td>Rotor assembly complete consisting of rotor shaft &amp; keys, End discs, Centre discs, distance rings, suspension bars, disc clamping nuts and shaft extension etc. but without hammers, bearings and pillow blocks, as applicable</td>
<td>1 Set</td>
<td></td>
</tr>
<tr>
<td>Cags bars, if applicable</td>
<td>4 Set</td>
<td></td>
</tr>
<tr>
<td>Breaker plate</td>
<td>4 Set</td>
<td></td>
</tr>
<tr>
<td>Liners</td>
<td>2 sets</td>
<td></td>
</tr>
<tr>
<td>Suspension bars</td>
<td>4 Set</td>
<td></td>
</tr>
<tr>
<td>Kick-off plate</td>
<td>4 Set</td>
<td></td>
</tr>
<tr>
<td>Screen plate upper &amp; lower</td>
<td>4 no. each</td>
<td></td>
</tr>
<tr>
<td>Tramp iron pick up plate</td>
<td>2no. each</td>
<td></td>
</tr>
</tbody>
</table>

### J. Vibrating screening feeder

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearings</td>
<td>2 no. of each type &amp; size</td>
<td></td>
</tr>
<tr>
<td>Seals</td>
<td>2 no. of each size</td>
<td></td>
</tr>
<tr>
<td>Liners</td>
<td>1 sets</td>
<td></td>
</tr>
<tr>
<td>Screen plates</td>
<td>10 sets</td>
<td></td>
</tr>
<tr>
<td>Complete vibrating assembly consisting of all rotating parts including drive &amp; driven unbalanced shafts including bearings, casing spring, vibrating blocks, main shaft, sheave &amp; unbalanced weights, (as applicable).</td>
<td>1 set of each type and rating and direction</td>
<td></td>
</tr>
<tr>
<td>Hoses (if applicable)</td>
<td>2 set</td>
<td></td>
</tr>
<tr>
<td>Drive unit assembly (including electric motor, hydraulic pump, hydraulic motor, flexible shaft, gear box, (as applicable)</td>
<td>1 set</td>
<td></td>
</tr>
</tbody>
</table>

### K. Electric hoists
<table>
<thead>
<tr>
<th><strong>L. Flap gates (including that of trippers)</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit switch</td>
<td>8 nos. of each type &amp; rating</td>
</tr>
<tr>
<td>Actuator (complete with motor, gear box, limit switches etc.)</td>
<td>1 nos. of each type &amp; rating</td>
</tr>
<tr>
<td>Oil seals of Actuator</td>
<td>2 nos. of each type &amp; rating</td>
</tr>
<tr>
<td>Flap gate shaft</td>
<td>1 nos. of each type &amp; rating</td>
</tr>
<tr>
<td>Pressure nut</td>
<td>12 nos. Of each type &amp; size</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>M. Rack &amp; pinion gate</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit switch</td>
<td>2 no. of each type &amp; size</td>
</tr>
<tr>
<td>Rollers with bearings</td>
<td>2 no. of each size</td>
</tr>
<tr>
<td>Motor gear box assembly</td>
<td>1 set of each type</td>
</tr>
<tr>
<td>Actuator (complete with motor, gear box, limit switches etc.)</td>
<td>1 nos of each type &amp; rating</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>N. Travelling tripper</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete drive assembly including gear box, coupling, brake etc.</td>
<td>1 set</td>
</tr>
<tr>
<td>Complete internals of speed reducer (including input shaft, output shaft, gear set)</td>
<td>1 set of each size &amp; type</td>
</tr>
<tr>
<td>Bearings for reducer</td>
<td>2 sets</td>
</tr>
<tr>
<td>Drive axle with wheels, plummer blocks, bearings etc.</td>
<td>1 set</td>
</tr>
<tr>
<td>Oil seals</td>
<td>2 nos. of each size</td>
</tr>
<tr>
<td>Non-drive axle with wheels plummer blocks, bearings etc.</td>
<td>1 set of each type</td>
</tr>
<tr>
<td>Chain assembly with sprockets</td>
<td>1 set of each type &amp; size</td>
</tr>
<tr>
<td>Festoon Roller assembly for flexible cable</td>
<td>4 Nos</td>
</tr>
<tr>
<td>Pulleys and plummer block bearings</td>
<td>1 no of each type</td>
</tr>
<tr>
<td>Plummer block with bearing for cable reel drums</td>
<td>1 set of each type</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>O. Screw conveyor/feeder</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearings</td>
<td>100% of installed qty</td>
</tr>
<tr>
<td>Complete screw with keys</td>
<td>1 set</td>
</tr>
<tr>
<td>Coupling complete</td>
<td>1 set</td>
</tr>
<tr>
<td>Seals</td>
<td>1 set</td>
</tr>
<tr>
<td>Gear Reducer, if applicable</td>
<td>1 set</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>P. Other coal &amp; ash Handling Equipments/System</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>All other coal &amp; ash Handling equipments/system (e.g., Ash slurry sump)</td>
<td>Bidder to provide &amp; mention in offer</td>
</tr>
</tbody>
</table>
Notes:

1) The above spares do not include installed spares as well as commissioning spares. The above shall be purely ware house spares.

2) Set means complete replacement of particular part in one machine.

3) Wherever "Each Type" is specified, it means "of the Type/make/model/size/rating and exactly replaceable".

4) Wherever "% qty." is specified, LSTK Contractor to quote in next higher rounded figure.

5) LSTK Contractor shall submit list of mandatory spare parts of all other items not covered in above spare list.

2.15 Fire Fighting

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>Quantity (% of total installation qty. or as specified)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hose box, RRL hose with couplings, jet nozzle with branch pipe, hose reel with nozzle, hydrant valve, landing valve</td>
<td>5% per item.</td>
</tr>
<tr>
<td>2</td>
<td>Monitor per type &amp; capacity</td>
<td>1 no.</td>
</tr>
<tr>
<td>3</td>
<td>Portable fire extinguisher per type &amp; capacity (upto 10 kg)</td>
<td>1%</td>
</tr>
<tr>
<td>4</td>
<td>Wheel mounted fire extinguisher per type &amp; capacity (greater than 10 kg)</td>
<td>1 no.</td>
</tr>
</tbody>
</table>

3.0 VENDOR’S RECOMMENDED SPARE PARTS

Contractor shall submit list of recommended spare parts of specialised items not covered under Mandatory spares, along with itemised price. Owner will review and decide the recommended spares required for the project.

General Notes:

1) The above spares do not include installed spares / commissioning spares. The above shall be Mandatory spares only.

2) Set means complete replacement of particular part in one machine/equipment/Fired heater etc.

3) Item wise price against each item shall be furnished.

4) Wherever "Each Type" is specified, it means "of the Type/make/model/size/rating and exactly replaceable"

5) Wherever "% qty." is specified, LSTK Contractor to quote in next higher rounded figure

6) Out of % age spares and minimum qty specified against each item - higher of the two shall be supplied.

7) Spares mentioned above to be offered as mandatory spares. However, if these spares are not used in the equipments being offered / supplied, the same need not be supplied. Bidder shall
clearly indicate against each such spare that these spares / items are not used in their equipments.

8) The above is owner’s recommended list of spares. The supplier may add other items as per their recommendations.

9) The quotation should contain sectional drawing showing location & part no. (For exact identification) & material specification.

10) LSTK Contractor to supply all commissioning spares for all necessary equipment’s for smooth & trouble free operation of complete system.

LSTK Contractor to supply all mandatory spares parts as per the list for all necessary equipment’s for smooth & trouble free operation of complete system.

Itemwise Price List to be furnished by LSTK Contractor with validity of 2 Years for 2 years Bidder’s recommended Operational Spares for smooth & trouble free operation of complete system. However these prices shall not be part of LSTK bid.

4.0 MAINTENANCE TOOLS AND TACKLES

The Contractor shall include all necessary maintenance tools required for maintenance of the Static equipment/Boiler supplied by him. The tools included by the Contractor shall cover all minimum maintenance tools considered necessary by the Contractor. A comprehensive list of maintenance tools shall be furnished. For some of the equipment/systems, requirement of maintenance tools and tackles has been specified in Data Sheets. Contractor shall necessarily supply these tools in addition to other tools and tackles as required.
SECTION : VI – 11.0

OWNER’S ENGINEERS IN LSTK CONTRACTOR’S OFFICE

PLANT : STEAM GENERATION PLANT

PROJECT : INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA
## CONTENTS

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<th>Description</th>
<th>Sheet Number</th>
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</thead>
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<tr>
<td>1.0</td>
<td>Owner’s Engineers In LSTK Contractor’s Design and Detailed Engineering Office</td>
<td>3</td>
</tr>
</tbody>
</table>
1.0 OWNER'S ENGINEERS IN LSTK CONTRACTOR'S DESIGN AND DETAILED ENGINEERING OFFICE:

1.1 LSTK Contractor shall provide to Owner's Engineers in LSTK Contractor's Design and Detailed Engineering Office the following facilities and services free of charge:

The basis is fifteen (15) man months not exceeding three (3) Engineers at any time.

1.1.1 Fully furnished offices: one double occupancy office, one single occupancy office. A conference table shall be provided in the single occupancy office.

1.1.2 Office equipment for exclusive use by Owner's Engineers shall be:

- 1 Scanning machine
- 1 Speaker-type telephone per office
- 1 PC with internet per engineer and printing facility
- 1 Photocopying machine

1.1.3 Office stationery

1.1.4 Local transportation from residence to office and vice versa by means of car or car pool transportation.

1.1.5 Telephone services in LSTK Contractor's Design and Detailed Engineering office as follows:

a) Cost of local and domestic telephone calls is in LSTK Contractor's fixed price.

1.1.6 Owner's Engineers offices should be near LSTK Contractor's project team (as far as possible) and can access to LSTK Contractor's general computer services of the non confidential nature, computer network and the Engineers shall be authorized to use Internet and e-mail for inter office and other countries and use the video teleconference.
SECTION : VI – 12.0

TRAINING OF OWNER’S PERSONNEL

PLANT : STEAM GENERATION PLANT

PROJECT : INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA
## CONTENTS

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<th>Description</th>
<th>Sheet Number</th>
</tr>
</thead>
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<td>3</td>
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<td>3</td>
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<td>3</td>
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<td>4</td>
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<tr>
<td>6.0</td>
<td>Management and Co-ordination of Training Services</td>
<td>4</td>
</tr>
</tbody>
</table>
1.0 GENERAL:

Given below is a typical program to train Owner’s Operation and Maintenance manpower in similar plants. Under this program nominated personnel shall be trained at:

- LSTK Contractor’s Detailed Engineering Office
- LSTK Contractor’s other Similar Plant in operation

2.0 OBJECTIVES OF MANPOWER TRAINING:

2.1 The objectives of training program shall be to transfer Technology and develop technical expertise in a core of individuals so that there is a pool of knowledge among Owner’s personnel which can be used to operate and maintain complete plants along with trouble shooting and to handle emergency situations envisaged during operation. The basic objective of training shall comprise of following main elements:

2.1.1 Owner’s manpower shall receive sufficient detailed instructions & exposures on the plants to enable them to carry out normal operations, to take corrective action in the event of upset conditions, and to set up routine operating and maintenance procedures.

2.1.2 Owner’s manpower shall be able to develop a thorough understanding of the plants and the know-how and processes behind it, be in a position to take positive and corrective action to prevent any upset and breakdown conditions from occurring, and to optimize plants’ operations, maintenance and organization.

3.0 REQUIREMENT OF TRAINED PERSONNEL:

Requirement of Technical Personnel for the plants shall be demonstrated to Owner by LSTK Contractor based on organisation chart of similar Plants indicating the total number of personnel required or operation, maintenance, laboratory works, etc.

4.0 TRAINING PROGRAM: CONTENT AND TIMING:

4.1 Title: Technology Training Course

<table>
<thead>
<tr>
<th>Objective</th>
<th>To train Process Engineers and Senior Operations’ Personnel. It provides participation with theoretical and practical knowledge and skills required for efficient and safe operation of the plants.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>This course describes the process flow and equipment, process control, maintenance procedures, analytical procedures, metallurgy and safety. Process and catalyst and adsorbent and desorbent chemistry (as required) and effects of process variables are carefully explained. Plants start-up, shutdown, emergency procedures and production quality control are discussed in detail along with a trouble shooting analysis. Each participant will receive a Technology Training Manual.</td>
</tr>
<tr>
<td>Duration</td>
<td>1 Week</td>
</tr>
<tr>
<td>Trainers</td>
<td>One LSTK Contractor’s Instructor cum coordinator</td>
</tr>
<tr>
<td>Participants</td>
<td>Maximum 08 (Eight)</td>
</tr>
<tr>
<td>Location</td>
<td>LSTK Contractor’s Detailed Engineering Office.</td>
</tr>
</tbody>
</table>
4.2 Training Courses at the LSTK Contractor's other Similar Plant Site:

4.2.1 Title: Process Operation training Course

<table>
<thead>
<tr>
<th>Objective</th>
<th>To provide a basic overview of process chemistry, operating variables and process control suitable for foreman, control room operators and outside. Start-up, Shut-down, Safety and Emergency procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>Description of Process flow and control, Equipment of Plants, Routine duties and operating emergency procedures.</td>
</tr>
<tr>
<td>Duration</td>
<td>02 Weeks</td>
</tr>
<tr>
<td>Trainers</td>
<td>Two LSTK Contractor’s Technical Advisors.</td>
</tr>
<tr>
<td>Participants</td>
<td>Maximum 08 (Eight)</td>
</tr>
<tr>
<td>Location</td>
<td>LSTK Contractor ‘other Similar Plant Site</td>
</tr>
</tbody>
</table>

4.2.2 Training as indicated in respective Design Philosophy (Section 5.0) shall also be provided by LSTK Contractor in Vendor’s works/ Plant.

5.0 LANGUAGE OF TRAINING:

All training shall be conducted in English language.

6.0 MANAGEMENT AND COORDINATION OF TRAINING SERVICES:

LSTK Contractor shall appoint a Training Manager to manage and coordinate training services for this Project. Owner for his part shall appoint a Training Manager to coordinate with LSTK Contractor. Owner’s training Manager shall be responsible for discipline of trainees during all phases of training, inside and outside India.
SECTION : VI – 13.0

INFORMATION REQUIRED IN TECHNICAL PROPOSAL

PLANT : STEAM GENERATION PLANT

PROJECT : INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA
1.0 INFORMATION REQUIRED IN THE TECHNICAL PROPOSAL

1.1 General

1.1.1 Comprehensive Engineering Specification/Standards and Design Codes for all types of Equipments/items including Mechanical, Electrical, Instrumentation, Civil & Structural proposed to be adopted by the LSTK Contractor.

1.1.2 Technical particulars, technical literature, drawings of the equipment offered and other details stipulated under design philosophy for respective equipment/ facility.

1.1.3 Type test certificates of the equipment offered.

1.1.4 Hazardous area classification drawing.

1.1.5 Construction Power requirement.

1.1.6 List of consumables, including first fill of oil & lubricants (including meeting short fall thereof till handing over) with quantities included in offer.

1.1.7 Specifications of Catalysts, Chemicals and Raw Materials and their estimated Initial and yearly requirement.

1.1.8 List of spares required for erection & Commissioning, performance guarantee tests till handing over of installation with quantities required.

1.1.9 Services considered to be provided by Owner at battery limit with specification & details of such services.

1.1.10 Details of Shop & Field Testing and Inspection Procedures proposed to be adopted. Inspection of equipment & machinery should be carried out by a Third Party Inspector. Owner also has the right to inspect any equipment, machinery at any stage.

1.1.11 Master Time Schedule in latest version of Primavera showing all the activities from date of receipt of LOI/ FOI and till handing over of complete installation.

1.1.12 An Implementation Plan showing man-power deployment schedule during various stages of implementation period, including peak requirements. LSTK Contractor shall indicate the schedule, category and number of personnel proposed for supervisory services during different phases of work, indicating clearly as to how many of them would be deployed by LSTK Contractor.

1.1.13 Project Plan showing Project Organisation, Project team, Project services offered by the LSTK Contractor at home office and at site. A time schedule for the complete project in the form of a Bar Chart and Network indicating the time allocated for various activities.

1.1.14 Quality Assurance & Quality Control procedure to be followed by LSTK Contractor for the implementation of this project.

1.1.15 List of all construction equipments, tool-tackles & man power resources proposed to be used.

1.1.16 List of Deviations. LSTK Contractor shall submit list of deviations to technical NIT indicating clearly clause-wise deviation from NIT. Any deviation listed other than in deviation list shall not be considered.

1.1.17 List of Recommended Spare part (for 2 Years Operation & Maintenance). Complete list of itemised spare part for all Process, Mechanical, Electrical, Instrument items considered for this project.
1.2 **Experience in executing similar orders**

Bidder shall submit list of Steam Generation Plants completed in last 10 years including the orders under execution indicating following:

1.2.1 Name of the Project with capacity, scope of work involved, order value & location.
1.2.2 Name of the client
1.2.3 Date of issue of order
1.2.4 Date of completion as per order
1.2.5 Date of actual completion (or % progress for ongoing projects till date of submission of bid for this project)
1.2.6 Performance certificate issued by owner.
1.2.7 Reasons for delay in completion, if not completed within completion date specified in order.

1.3 **Performance Parameters**

1.3.1 Performance parameters will be as per Section-VI-8.0 of NIT.
1.3.2 Performance of all other equipment shall be checked as per relevant standards for specified capacity, turn down, specified outputs and noise levels.
1.3.3 Bidder shall also very clearly and unambiguously describe in his offer

- The format that would be used for recording the observations and the correction factors/ formulae’s etc that will be used (a) for corrections and (b) for evaluation of performance.
- Detailed methodology that would be adapted for conducting performance evaluation,
- The test conditions,
- The points where measurements shall be made and
- The detailed list of instruments (with accuracy class) that would be arranged and used by them for performance evaluation.
- The list of loads (electrical) that would not be considered for the purpose of computing guaranteed value of consumption of auxiliaries.

1.4 **Summary Of Technical Parameters of Major Equipment**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Equipment Description &amp; Quantities</th>
<th>Make &amp; type Country of manufacture</th>
<th>Applicable std.</th>
<th>Rating as per design conditions of tender</th>
<th>Guaranteed tech. Data</th>
</tr>
</thead>
</table>

1.5 **Information to be furnished regarding Process**

1.5.1 Basis of Design

Design basis for all Process, Mechanical, Electrical, Instrumentation, Civil & structural items.

1.5.2 Process Description.
A detailed description of the process offered, including overall process scheme and the specific merits of the process scheme being offered.

1.5.3 Process Flow Diagram / Material Selection diagram
Process flow diagrams, Material Selection Diagrams indicating the major equipment in proper Flow sequence, Flows, Temperatures, Pressures, Compositions, Pressure drops for critical equipments, Critical Instrumentation, Control points and the material of construction adopted for the major lines.

1.5.4 Utility flow diagram.

1.5.5 P&I Diagrams for all process and package items.

1.5.6 Material and Energy Balances
Material and Energy Balances shall cover all process route, showing input and output utility streams as well as composition, volumetric flow, molecular weight and densities of principal process streams at inlet and outlet of each equipment.

1.5.7 Detailed Steam, Condensate and Cooling water Balance
Detailed Steam, Condensate and Cooling water Balance diagram showing production and consumption at different points for each level of steam pressure, Cooling Water Balance showing In/Out temperatures, cooling water flow to each exchanger using cooling water, process and condensate flows from the process plants.

1.5.8 Utility Requirements (Anticipated Normal and Peak requirements of each utility).

1.5.9 Start-up Requirements of Utilities such as Inert Gas, Steam, Instrument Air, Electrical Power etc.

1.5.10 Emergency Power Requirement and the list of equipments connected to it.

1.5.11 Instrumentation Control philosophy.

1.5.12 Plot Plan showing principal equipment and machinery including detailed floor plans and elevations. The plot plan should show clearances required, roads and all principal pipe racks.

1.5.13 Plant Battery Limit termination point details.

1.5.14 Turndown capability and operating range.

1.5.15 System suggested for on-line product quality control

1.6 Information to be furnished regarding Boiler

1.6.1 The net capacity of boiler

1.6.2 Number & type of boilers

1.6.3 Steam pressure at the outlet of Main Steam Stop Valve during the controlled load

1.6.4 Steam temperature at the outlet of Main Steam Stop Valve

1.6.5 The minimum continuous load

1.6.6 At steady state operation the difference in temperature between the ambient and the outside surface of insulation

1.6.7 The maximum noise pressure level at 1.0m distance for the boiler and any associated equipment within 1 m distance will be equal to or less than

1.6.8 Conditions considered for the purpose of design of boiler viz. Ambient temperature, RH, Boiler feed water temperature,
1.6.9 Emission at outlet of ESP & stack
1.6.10 Boiler efficiency for varying GCV
1.6.11 Curves for radiation losses
1.6.12 Curves for Condenser performance for varying ambient temperature
1.6.13 Specification sheet with complete details.
1.6.14 Product Steam

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Units</th>
<th>Boiler Maximum Continuous Rate</th>
<th>At 100 % (Normal)</th>
<th>At 40% (Turn – Down)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>No. of Boilers</td>
<td></td>
<td>2W+1S</td>
<td>2W+1S</td>
<td>2W+1S</td>
</tr>
<tr>
<td>II.</td>
<td>Capacity of Each Boiler</td>
<td>MT/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III.</td>
<td>Internal consumption of Boiler</td>
<td>MT/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV.</td>
<td>Steam Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Silica as SiO₂, ppm</td>
<td>&lt; 0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pH</td>
<td>9-9.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conductivity, µS/cm (at 25°C)</td>
<td>&lt; 0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Iron (Fe) mg/kg</td>
<td>&lt;0.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Na+K mg/kg</td>
<td>&lt;0.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Copper mg/kg</td>
<td>0.003</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V.</td>
<td>Pressure (Min./ Nor./ Max.)</td>
<td>Kg/Cm²g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(110/115/120)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI.</td>
<td>Temperature (Min./ Nor./ Max.)</td>
<td>°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(515/520/525)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VII.</td>
<td>Quantity of total Steam to be exported at LSTK Contractor B.L.</td>
<td>MT/hr</td>
<td>LSTK to fill</td>
<td>LSTK to fill</td>
<td>LSTK to fill</td>
</tr>
</tbody>
</table>

1.7 Information to be furnished regarding Turbine
1.7.1 Specification sheet with complete details
1.7.2 Rated Capacity
1.7.3 Steam pressure at the inlet of turbine
1.7.4 Steam temperature at the inlet of turbine
1.7.5 Detailed manufacturing programme
1.7.6 Equipment layout with main overall dimensions including those required for foundations and piping design for Turbine and auxiliaries.
1.7.7 Performance curves for steam turbine comprising (but not limited to):
   (a) steam consumption versus kW (for various extraction rate in case of extraction turbine)
   (b) overall efficiency vs. load curve
   (c) steam consumption correction curves
   (d) curve showing variation of exhaust temperature with inlet flow (i.e. under various loads):
      - for change in live steam pressure
- for change in live steam temperature
- for change in speed from governor set point speed to max. continuous speed
- for change in cooling water inlet temperature from 25°C to 35°C

(e) Heat rate & Turbine output Vs exhaust pressure
(f) Heat rate & Turbine output Vs inlet steam pressure
(g) Heat rate & Turbine output Vs inlet steam temperature
(h) Curves for radiation losses

1.8 **Information to be furnished in respect of Fans & Blowers**

1.8.1 Specification sheets completely filled
1.8.2 Characteristic Curves - Performance curves, showing discharge pressure, capacity, and brake horse power at the inlet specified conditions (Pressure, capacity, temperature, molecular weight).
1.8.3 Details of Lubrication and sealing system
1.8.4 Data for selection of motor
1.8.5 General Arrangement Drawing with all main dimensions, size and location of connections for ducting with all horizontal & vertical clearance necessary for installation and disassembly.
1.8.6 Reference list indicating duty condition, location, year of installation, name of client etc.
1.8.7 GA drawing with all details & dims. Including fan, drive, motor
1.8.8 Description of capacity control with details

1.9 **Information to be furnished in regarding piping**

1.9.1 Equipment Layout plan showing location of various equipment based on relevant appropriate norms.
1.9.2 piping layout drawing.
1.9.3 Detailed Technical Specifications of piping & valves with approximate tonnage/quantities in the form of Bill of Material.
1.9.4 Plant battery limit tie point details.

1.10 **Information to be furnished in respect of Coal Crusher House**

1.10.1 Scheme / Layout drg. of Coal Crusher House
1.10.2 GA Drawings of all the Coal Crusher House equipments along with detail specification of each equipment
1.10.3 Mechanical G.A drg. of Coal Crusher House buildings

1.11 **Information to be furnished in respect of Ash Handling System**

1.11.1 Scheme / Layout drg. Of Ash handling system
1.11.2 PFD of Ash handling System
1.11.3 GA Drawings of all the Ash handling System equipments along with detail specification of each equipment
1.11.4 Mechanical G.A drg. of all buildings (e.g. Silo, Bag house building etc.) showing Ash handling equipments
1.12 Information to be furnished in respect of Static Equipment
1.12.1 Filled in Data Sheets of pressure equipment along with outline sketches showing thickness of main parts, weight (erection & operating) and anchorage details
1.12.2 General arrangement for package items showing plan, elevation & end view
1.12.3 Details of internals including demister, i.e. make and model No., free volume, wire diameter, surface area, and density of material and separation efficiency.

1.13 Information to be furnished regarding Pumps
1.13.1 Pump specification sheet with complete details in Performa enclosed with enquiry
1.13.2 Dimensional outline drawing
1.13.3 Lube oil schematic
1.13.4 Performance curves
1.13.5 Foundation assembly drawing of pump with driver & all accessories mounted on base plate
1.13.6 Reference list for pumps supplied in past for similar duty conditions.

1.14 Information to be furnished in respect of EOT Cranes

1.15 Information to be furnished in respect of Hoists

1.16 Information to be furnished in respect of Elevators

1.17 Information to be furnished in respect of Environment pollution control measures:
Designed values of environment & effluent pollutants vis-a-vis values as per statutory norms shall be mentioned by bidder.
Both continuous and intermittent gaseous emission shall be indicated.
Details of Effluent Streams and Treatment System proposed within Battery Limits and required outside Battery Limits. Design and Guaranteed quality and quantity of various gaseous emissions and liquid effluents and solid waste at Battery Limits.

1.18 Information to be furnished in respect of emissions from stack
Designed values of emissions vis-a-vis values permitted as per statutory norms shall be mentioned by bidder.

1.19 Information to be furnished in respect of Electrical
1.19.1 Single line Power Distribution Diagram for Complete electrics included in his offer up to incomers, bus-couplers of switchboards, PCCs, PMCCs, MCCs, Distribution Boards, MLDBs indicating maximum demand on each bus-section,
1.19.2 Protection/ metering and interlocking scheme.
1.19.3 Load List indicating rated and absorbed power of loads in kW indicating voltage, rpm, speed variation requirement, type of starting/ control, duty type (Continuous/ Intermittent/ Standby) with type of power supply (Normal/ Emergency/ Critical).
1.19.4 Single line diagram for evacuation of power to sub-stations in various plants through Main receiving & Power Distribution sub-station
1.19.5 Layout of equipment proposed in Substation, control room, sub-stations, Electrical Rooms and other premises for installing of facilities (electrical, LMS) proposed by him to meet stipulations in ITB.
1.19.6 Hazardous area classification drawing.

1.19.7 'List of Deviations-Electrical', if any.

1.19.8 'List of Exclusions-Electrical', if any.

1.20 Information to be furnished in respect of Instrumentation

1.20.1 Consolidated list of drawing & documents.

1.20.2 Details of Instrumentation System including proposed models etc. as also details of the proposed control systems (DCS) Safety Interlock and Trip system

1.20.3 List of all control valves with purchase specifications, material of construction, codes/standards used

1.20.4 Instrumentation Control Philosophy, Logic Diagrams & Safety valve Specifications

1.20.5 Instrument Index & I/O List

1.20.6 Catalogue & technical literature of Instrument along with their accessories.

1.20.7 Deviation if any, from the technical spec. giving justification for the same.

1.20.8 Certificates from recognised authority for (a) degree of protection against environment (b) for intrinsic safety/ Ex-proof execution.

1.21 Raw Material & Utility Consumption:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Raw Material &amp; Utility</th>
<th>Units</th>
<th>Boiler Maximum Continuous Rate</th>
<th>At 100 % (Normal)</th>
<th>At 40% (Turn – Down)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>Coal</td>
<td>MT/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II.</td>
<td>Fluxant</td>
<td>MT/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III.</td>
<td>DM Water</td>
<td>M³/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV.</td>
<td>Power Consumption</td>
<td>KW/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V.</td>
<td>Cooling water Make-up</td>
<td>M³/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI.</td>
<td>Any other water requirement, if any</td>
<td>M³/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VII.</td>
<td>Fuel gas</td>
<td>Nm³/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIII.</td>
<td>Instrument Air</td>
<td>Nm³/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IX.</td>
<td>Plant Air</td>
<td>Nm³/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.22 Plant Start Up & Shut Down Requirement:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Item (Bidder to specify)</th>
<th>Start-up</th>
<th>Shutdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Bidder to specify each item with quantity, quality at their Battery Limit required for start-up and Shutdown

1.23 Catalyst Requirement (If Any):
Bidder to specify Item-wise information on catalysts used in their process as per pro-forma given below:

<table>
<thead>
<tr>
<th>Type</th>
<th>Supplier</th>
<th>Loaded Volume</th>
<th>Expected Life</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>m³</td>
<td>Years</td>
</tr>
</tbody>
</table>

1.24 Effluents And Emissions
1.24.1 Liquid Effluents:
   a) Continuous
   b) Intermittent
1.24.1 Gaseous Emissions:
   a) Continuous
   b) Intermittent

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SECTION – VI - 14.0

SITE WORKING AND SAFETY CONDITIONS

PLANT: STEAM GENERATION PLANT

PROJECT: INTEGRATED COAL BASED FERTILISER COMPLEX
AT TALCHER, ANGUL DISTRICT, ODISHA (INDIA)
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### 1.0 SITE LOCATION
The proposed project will be located within the premises of existing closed coal based Ammonia-urea complex of TALCHER FERTILIZERS LIMITED, Talcher, ANGUL DISTRICT, ODISHA (INDIA).

2.0 SITE ESTABLISHMENT

2.1 The LSTK contractor shall provide all huts, stores, tarpaulins and other covers for the accommodation of his staff, workmen and materials. All materials likely to deteriorate in the open shall be stored under suitable cover.

2.2 The LSTK contractor shall advise the owner within 15 days of the placement of LOI his space requirement which shall include for office, covered storage, open storage, fabrication space, etc. Depending on availability & requirement, space shall be allotted to the contractor for the duration of this contract. He will not be permitted to make use of any other space without the sanction of the Owner. The use of this space shall strictly be made for the execution of this contract only. The sanitary conditions of the ground in or around such structures shall, at all times, be maintained by the contractor in a manner satisfactory to the owner.

2.3 The security of the LSTK contractor's equipment and materials is his own responsibility.

2.4 The LSTK contractor's shall clear away periodically any rubbish, scrap materials, etc. and dump the same in the area indicated by the owner/consultant. All construction material shall be neatly stacked in an orderly manner as directed by the owner and care shall be taken to allow proper access to workmen and easy movement of men, vehicles, cranes and materials.

2.5 The LSTK contractor shall maintain all the drawings carefully mounted on the board of appropriate size and well protected from the ravages of weather termites and other insects.

2.6 The LSTK contractor shall not permit the entry to the site of any person not directly connected/concerned with the work without first having obtained the written permission of owner.

2.7 The LSTK contractor shall submit a list of plant, equipments, tools, tackles, etc. which he will use, to perform the work. The contractor shall submit a list in duplicate of all materials, tools and tackles etc. brought inside the plant site duly signed by owner's security staff as per the rules laid by owner. These tools, etc. shall not be removed from the site till the completion of job. A gate pass must be obtained from the owner in order to remove from site any plant, machinery, tools, materials and equipment.

2.8 All items such as instructions and other pertinent data regarding erection/commissioning and maintenance should be typed and classified for transmittal in a manner approved by the owner.

2.9 All employees of the LSTK contractor shall conform to any rules of conduct, etc. established by owner. Failure to comply with the rules of conduct will be sufficient cause for removal of such person from the site.
2.10 The LSTK contractor will be responsible for providing all plant, tools and tackles, consumables and scaffolding required for the execution of his work as per the best engineering practices.

2.11 The receipt, unloading, movement and storage at site of all the LSTK contractor plant, tools and materials is his responsibility. The receipt, movement & storage of material issued by owner also shall be the responsibility of the Construction Contractor.

2.12 ELECTRICITY

Construction power shall be arranged by LSTK contractor as per Section 7.0 Clause no. 3.0 of this contract.

2.13 CONSTRUCTION WATER

The LSTK contractor shall communicate his water requirements to the Owner within 7 days of the placement of LOI. Construction water shall be arranged by LSTK contractor as per Section 7.0 Clause no. 3.0 of this contract.

2.14 FIRST AID

The LSTK contractor may have access to the Owner's qualified first aid personnel and ambulance, in case of accidents, if available. The contractor will, however provide a first aid post for minor injuries to their staff.

3.0 SUPERVISION OF WORK

3.1 The LSTK contractor shall submit to the Owner resume of his site supervisors for approval prior to commencement of the work. Once approved, the LSTK contractor shall not remove his site supervisors without prior concurrence of the Owner.

3.2 The entire work is to be completed as per the agreed time schedule. The programme of work in details shall be submitted by the LSTK contractor before commencement of work. The detailed programmes prepared by the LSTK contractor shall conform to the targets set forth in the time schedule and will be subject to the approval of the owner. All the work shall be carried out in such a manner that the work of other agencies at site is not hampered due to any action of the LSTK contractor.

4.0 INSPECTION

The work of the LSTK contractor shall be subject to inspection by the Owner at all times.

5.0 EMPLOYMENT OF LABOUR

5.1 The LSTK contractor will be expected to employ on the work only his regular skilled employees with experience of this particular work. The permission of the Owner must be obtained before tradesman is recruited locally for the work. This rule does not apply to unskilled labour. No female labour shall be employed in dark hours/ i.e. hours prohibited under the applicable law. No person below the age of eighteen years shall be employed at any point of time.
5.2 All traveling expenses including provision of all necessary transport to and from site, lodging allowances and other payments to the LSTK contractor employees are his own responsibility.

5.3 The hours of work on LSTK Contractors / Owner and contractor shall adhere to the same.

5.4 All Construction contractors employees shall wear safety helmet and such identification marks as may be provided by LSTK contractor on work site and duly approved by Owner.

5.5 All notices displayed on the site and any instructions issued by the Owner shall be strictly adhered to by the LSTK Contractors and/or his LSTK contractor employees.

5.6 It shall be the responsibility of LSTK contractor to provide suitable accommodation including necessary facilities for their labour and staff.

5.7 LSTK contractor will arrange for Ration Cards and Permits for labour as per statutory provisions for its labour, as necessary.

5.8 The LSTK contractor shall be required to maintain employment records as covered in relevant Acts and produce documentary evidence to the effect that he has discharged his obligations under the Employees Provident Fund Act 1952 for the workmen working at site.

5.9 In case the Owner becomes liable to pay any wages or dues to the labour of the LSTK Contractors or his contractor or any Govt. agency under any of the provision of the Minimum Wages Act, Workmen Compensation Act or any other law due to act of omission of the contractor, the Owner may make such payment and shall recover the sum from Contractor's bills or any other dues.

6.0 COMPLETION OF WORK

Before finally leaving site, all the LSTK contractor store, huts, plant, tools and rubbish shall be removed and the site left clean and tidy. The space allocated by Owner shall be vacated and handed over to the Owner.

7.0 WORKING AND SAFETY REGULATIONS

7.1 The LSTK Contractor shall observe all statutory safety and legal requirements regulations issued by Central and State Governments applicable to the work as well as any local regulations applicable to the site issue by the consultant or any other authority.

7.2 Particular attention is drawn to the following:

   a) In case of accident, the Owner shall be informed in writing forthwith. The LSTK Contractor shall strictly follow regulations laid down by Factory Inspector, Govt. and State authorities in this regard.

   b) LSTK contractor shall fence his plant, platforms, excavations etc.

   c) Compliance with all electricity regulations.
d) Compliance with statutory requirements for inspection and test of all lifting appliances and auxiliary lifting gear.

e) Safety belts proposed to be used, shall be got checked by Fire & Safety Department of LSTK Contractor / OWNER in written before use.

f) Before using the lifting or pulling equipment, LSTK contractor shall carryout load test which shall be witnessed by LSTK Contractor / OWNER.

7.3 Staircase, doors or gangways shall not be obstructed in any way that will interfere with means of access of escape.

7.4 No excavations will be started without the permission of the LSTK Contractor / OWNER, who will inform the LSTK contractor of the position of any pipes or cables known to be buried in the area. All excavations must be effectively railed off at all times, or completely boarded over properly marked during the hours of darkness by red warning lamps, using Flame proof warning lamps in non smoking areas. Debris or material which cannot be immediately removed must be heaped in such a way as to be immediately remove and also to leave adequate passage way. Any finds such as relics or antiques coins or fossils etc. shall be promptly handed over to the Owner.

7.5 The LSTK contractor will notify the Owner of his intention to bring on the site any equipment, such as, space heating or welding apparatus or any container holding liquid or gaseous fuel or other substance which might create a hazard. The Owner will have a right to prohibit the use of such equipment or to prescribe the conditions under which such equipment may be used. The LSTK Contractor will have the right to inspect any construction plant, and to forbid its use if in his opinion it is un-suitable or unsafe. No claim arising there from shall be made by the LSTK Contractor.

The LSTK contractor or any one acting on his instructions will not bring on to the site any radio active substance or any apparatus using such substances or any X ray apparatus until written permission and direction regarding the use of such equipment has been received from the Owner.

The LSTK contractor shall be responsible for the safe storage of the radio graphic sources or those of his Construction contractors.

7.6 The LSTK contractor will meet all requirements, and act on the instructions of the Owner where it is necessary to operate a permit to work system.

7.7 Where it is necessary to provide and/or store petroleum products or petroleum mixtures and explosive, the LSTK contractor shall be responsible for carrying out such provision and/or storage in accordance with the rules and regulation laid down in Petroleum Act 1934, Explosive Act 1948 and Petroleum and Carbide of Calcium Manual Published by the Chief Inspector of Explosive of India. All such storage shall have prior approvals of the Consultant. In case any approval or clearance from Explosive or any statutory authorities is required, the contractor shall be responsible for obtaining the same.

7.8 The LSTK contractor shall have his own Fire Fighting Extinguishers and Equipment.

7.9 The LSTK contractor shall be responsible for the provision of all safety notices safety equipments including the safety gadgets for his workmen required by both the relevant legislation and such as the Owner may deem necessary.
7.10 While working at heights, safety belts shall necessarily be used.

7.11 "LSTK contractor shall employ a safety officer for safe executing the construction activities of the project who will be responsible for implementing safety requirement contained in the documents. The safety officer shall possess a recognised degree in engineering discipline preferably, F&S or (Any branch of engineering) and had a post qualification construction experience of minimum two years. In addition, he/she shall also possess a recognised degree or diploma in industrial safety and preferably have adequate knowledge of the language spoken by majority of the workers at the construction sites. Contractor shall ensure physical presence of safety personnel at each work location wherever Hot Work permit is required. No work shall be started at site until above safety personnel are physically present at site. The contractor shall submit a safety organogram clearly indicating the lines of responsibility and reporting system and elaborate the responsibilities of safety personnel in the HSE MANUAL/Program. The contractor should furnish Bio-Data/Resume of the safety personnel as above, at least 01 month before the mobilization for PDIL/owner’s approval.

7.12 LSTK contractor shall use only steel planks and clamps executing scaffolding. Wooden planks and rope shall not be allowed for this purpose.

7.13 LSTK contractor shall use asbestos cloth to ensure falling of weld spatters down below during above ground welding to ensure safety of electrical cables and personnel and avoiding any fire hazards.

8.0 ELECTRICAL SAFETY REGULATIONS

8.1 In no circumstances will the LSTK contractor interfere with fuse and electrical equipment belonging to the owner or other contractors.

8.2 Before the LSTK contractor connects any electrical appliances to any plug or socket belonging to the other contractor or owner, he will -

   i. Satisfy the Owner that the appliance is in good working condition.

   ii. Uses of matching sixes plug & does not uses bare wire to insert in socket.

   iii. Inform the Owner of the maximum current rating, voltage and phase of appliance.

   iv. Obtain permission of the Owner dealing the sockets to which the appliance may be connected.

   v. Use distribution board with ELCB for feeding power to hand held tools.

8.3 The Owner will not grant permission to plug in until he is satisfied that-

   i. The appliance is in good condition and is fitted with a suitable plug.

   ii. The appliance is fitted with a suitable cable having two earth conductors, one of which shall be earthed metal sheath surrounding the cores.
8.4 No electric cable in use by the other LSTK contractor/owner will be distributed without prior permission. No weight of any description be imposed on any such cable and no ladder or similar equipment will rest against or be attached to it. Cables/Wires used shall be in good condition without cuts & in insulation & joints.

8.5 The voltage for all portable equipment e.g. drilling machines, temporary lighting etc. will not exceed 240 volts.

8.6 No work must be carried out on any live equipment. The equipment must be made safe and a “permit to work” issued before any work is carried out.

8.7 LSTK contractor shall employ electrician to maintain his temporary electrical installation.

8.8 Take necessary clearance for working in hazardous area.

9.0 REPORTING

a) The LSTK contractor must report the following information to the Owner in writing daily. Number of men employed, trades-wise,
   - Progress achieved;
   - Concrete pour card, if any.

b) If during excavation any materials such as but not limited to precious materials or treasure troves etc are found, the same shall be reported to owner immediately and shall be the property of owner.

10.0 GENERAL SAFETY REQUIREMENTS TO BE OBSERVED DURING SITE FABRICATION AND ERECTION BY THE CONSTRUCTION CONTRACTOR

1. Before starting the work, **LSTK contractor** should get safety work permit and should strictly follow instructions written by the concerned authority in work permit. Permit is required for all types of job i.e. Hot, Cold Excavation, Chipping, Grinding etc.

2. Smoking is strictly prohibited inside factory areas.

3. Safety appraisal and equipments shall be provided to workmen as per the nature of work. Welders shall use gloves, goggles, shields etc. during welding, gas cutting etc. All technicians shall use gloves, goggles during grinding, chipping etc. If any unsafe practice is observed Fire & Safety Sections or the authority issuing the work permit is authorized to stop the work without any prior notice.

4. Temporary fire extinguishers, water hose shall be available near work place and in case of fire, Owner’s Fire & Safety Section should be immediately informed by LSTK contractor from nearest available telephone. Project Manager should also be immediately informed.

5. LSTK contractor shall secure necessary insurance of his workmen for the entire duration of works under the contract. Owner is not responsible for any
accident/injury caused whatsoever, to any person employed by the Construction Contractor. However, LSTK contractor has to inform Owner's Fire & Safety Section about accident, if any, immediately.

6. Temporary switch boards, cables, wires and electrical equipments should be installed in accordance with standard electrical practice with proper earthing etc. and should have prior approval of LSTK Contractor / Owner electrical engineer. Switch board shall be suitably protected against rainwater. The cable used for welding machine should have flexible tough rubber sheathing.

7. Temporary cables and wires including welding cables should be routed as not to cluster the work areas. Also any possibility of damage to live wires by falling objects should be avoided. Temporary electrical lines for power & lighting shall run overhead or underground so that they should not hinder the movement of men, materials and vehicles.

8. Portable hand lamps being used by construction crew shall be preferably of 24 Volts supply bulb to be protected with safety shields.

9. Earthing for welding shall not be taken through existing structure or equipments due to the very explosive nature of the plant, raw materials, reaction during process and final product. There is every possibility of fire and explosion in the equipment due to electric spark caused by loose earthing connection etc.

10. LSTK contractor should be careful while excavating so that no underground cable or pipe line is damaged. As soon as any brick cover or underground cables are exposed he should stop the work and inform Construction Manager immediately for necessary action.

11. LSTK contractor should not leave any welding machine etc. running after the work is stopped. Before leaving the work place, Contractor should ensure that welding sets are disconnected from welding socket outlet.

12. All work areas shall be kept reasonably clear and clean for easy movement of men & material. Also all approach roads shall be free from obstacles for easy movement of cranes, vehicles, fork-lifts, trollies etc. and all debris shall be periodically removed.

13. All temporary structure and supports for erection purpose such as scaffolding, ladders, walkways, platform, shuttering etc. shall be sufficiently strong for safe use and to prevent collapse & accidental fall of workman. Same shall be removed immediately after the work is completed.

14. All workmen working at unsafe elevation during the construction activity such as concreting, plastering, welding, erection work, painting, insulation etc. shall be safe and sufficient passage and should be properly instructed to take necessary safety precautions and observe safe practice to prevent accidental fall. Safety belts and helmets shall be used wherever necessary.

15. All supervisors, welders, electricians, technicians, riggers, engaged in the work shall be adequately skilled, experienced and acquainted with standard rules, regulation & practices of the work.
16. All open trenches, pits and other excavation carried shall be barricaded out by Construction Contractor, to avoid accident.

17. All lifting tools, tackles & accessories shall be in good working condition and of suitable capacity for the purpose for which they are used. All certificates/permits/licenses etc. required under any law or regulation for the same shall be available and valid during the entire period of the execution of the work under this WO/Contract.

18. LSTK contractor shall not use any structure or equipments erected or under erection for fastening, lifting or flying tackle guy-ropes etc. which may impose such loads for which structure or equipments are not designed to carry. However, LSTK contractor has to get prior approval from Construction Manager of Owner before using beams, permanent structure for the above purpose.

19. When work is carried out at high elevations, it is the responsibility of the LSTK contractor to ensure that tools and materials are not left in a position where they can fall on peoples moving /working below. Where necessary, places below should be cordoned off and caution boards be provided by contractor. Also, LSTK contractor should not cut existing hand railing/structure.

20. Contractor’s men must not tamper with any machines, switches, valve or equipment not connected with their work. Welding holders should not be tested on running pipe lines.

21. Nylon rope should not be used for scaffolding where hot line is running nearby, because there is every possibility of wire rope catching the fire. Also, no scaffolding is to be made on hot as well as insulated lines.

22. Necessary sign boards clearly indicating “RADIOGRAPHY HAZARDS” on all the four sides of the cordoned area surrounding radiography source will have to be displayed by Construction Contractor. Surrounding area will be cordoned with the help of manila rope and his personnel will be kept for watching/guard on all the four sides to prevent entry of personnel till the radiography work is completed. Construction Contractor’s personnel should be able to communicate clearly/properly to stop entry of unauthorized personnel within the area cordoned for the radiography work.

Refuse Disposal

23. Refuse must be removed daily to prevent accumulation. Materials liable to cause persons to slip or trip and fall should be cleared immediately.

24. Refuse removal teams working after work hour should be organized where normal cleaning can not cope with the build up of waste materials.

25. Projecting nails should be removed or bent over.

Personal Protective Equipments
26. Helmets should be provided for all who are exposed to the dangers of falling material or structures they might strike against.

27. Suitable eye protection should be provided for all who are exposed to flying particles, harmful glare and dangerous substances.

28. In the handling of rough objects, gloves should be provided and used.

29. Safety footwear should be provided to all who are exposed to foot injury, should be good fitting and comfortable to wear.

30. Safety belts should be provided where other means are not practicable. Both the anchorage points and lifelines provided for attaching safety belts should be of adequate strength. The umbilical line should be fixed in such a way that user's freefall will not exceed 1 metre.

31. Catch net should be used where persons are liable to fall and these should be securely supported at a level as near as possible to the working level.

32. Noise defenders should be provided for work area where the noise level exceeds 85 dBA.

33. Respiratory protection should be provided by employers and used by workers where the dust level remains high and where control at source is not practicable.

**Inspection & Record Keeping**

34. Where defects render the scaffolds unsafe, they should be rectified immediately. Where this is not practicable, a sign should be put warning against using it.

**Winches**

35. Adequate foundations should be provided for winches.

**Lifting Gear**

36. All lifting gear and slinging should be tested before use and thereafter inspected regularly by competent engineers. Workers should also check the lifting gear visually before using them.

37. Each piece of lifting gear should bear its safe working load, its identification number and its last inspection date. It could in addition be colour coded according to due date of inspection.

38. Wire ropes should be preserved against rusting, kinking, fraying, birdcaging and heat damage. Defective wires should be destroyed to prevent recycling.

**Concrete Mixers**
39. Moving parts which are liable to become nip points, such as gears, chains and rollers should be guarded.

40. Where concrete mixers are driven by internal combustion engineers, exhaust points should be located away from the workers’ work station so as to eliminate their exposure to obnoxious fumes.

**Electrical Components**

41. All components and conductors used must be in good condition.

42. Proper junction boxes and distribution boards from which electric power could be tapped should be provided at every floor level.

**Demolition: General Provisions**

43. Uncontrolled collapse of walls or other structures under demolition should be prevented.

44. The throwing of materials over the sides of the buildings should not be permitted.

**Waste Handling**

45. Where demolition is carried out near public areas:
   a) Hoardings slopping inwards should be erected around the building.
   b) Protective nettings should be hung around the building to prevent materials falling outside the periphery shelter
   c) asbestos

Where asbestos materials are present, appropriate dust control and respiratory protection approved by the local authority must be used.

**Excavation: General Provisions**

46. Test for toxic gases should be carried out where their presence is suspected.

47. Exposure of shorings to vibration such as that produced by engines or vehicular traffic should be kept to a minimum.

**General – Ventilation, Fire Protection/Fighting**

48. Where flammable gas concentration could reach explosive levels, it may be necessary to provide intrinsically safe electrical equipments.

49. Adequate lighting and emergency lighting should be provided.

50. Adequate evacuation stairways should be provided for rapid evacuation in case of an emergency.
First Aid

51. Sufficient First Aid Boxes containing simple dressings and supplies should be provided on the site under the control of the foreman.

Awareness

52. The contractor shall brief the visitor about HSE precautions which are required to be taken before proceeding to site and make necessary arrangement to issue appropriate PPE’s like HELMET, Safety shoes etc. to the visitors. The contractor shall promote and develop consciousness about Health, safety and environment among all personnel working for the contractor. Regular awareness programmes and fabrication shop/work site meeting at least on fortnightly basis shall be arranged on HSE activities to cover hazards involved in various operations during construction phase. During the awareness program, step shall be taken by the contractor to motivate & encourage the workmen and supervisory staff by issuing/awarding them the tokens/gifts/mementos/ Monitory incentives.

A verbal warning shall be given to the workers during the first HSE violations. A written warning shall be issued on second violations and thereafter for the third violations; the services of worker shall be terminated. For all these violations, a penalties’ shall be imposed, separately on the contractor. Records of warning for each worker shall be kept in the records.

53. Penalty

The Contractor shall adhere consistently to all provisions of HSE requirements. In case of noncompliance’s and also for repeated failure in implementation of any of the HSE provisions, Consultant/Owner may impose stoppage of work without any cost & time implication to the Owner and/or impose a suitable penalty.

The amount of penalty shall be limited to 0.5 % (Zero decimal five percent) of the contract value for LSTK contract.

The amount of penalty applicable for the Contractor on different types of HSE violations is as below.
1. For not using personal protective equipment (Helmet, Shoes, Goggles, Gloves, Full body harness, Face shield, Boiler suit, etc.)
   Rs 500/- per day/ Item / Person.
2. Working without Work Permit/Clearance Rs 20000/- per occasion.
3. Execution of work without deployment of requisite field engineer / supervisor at work spot Rs. 5000/- per violation per day.
4. Unsafe electrical practices (not installing ELCB, using poor joints of cables, using naked wire without top plug into socket, laying wire/cables on the roads, electrical jobs by incompetent person, etc.)
Rs 10000/- per item per day.

5. Working at height without full body harness, using non-standard/ rejected scaffolding and not arranging fall protection arrangement as required, like handrails, life-lines, Safety Nets etc.
Rs. 10000/- per case per day.

6. Unsafe handling of compressed gas cylinders (No trolley, jubilee clips double gauge regulator, and not keeping cylinders vertical during storage/handling, not using safety cap of cylinder).
Rs 500/- per item per day.

7. Use of domestic LPG for cutting purpose / not using flashback arresters on both the hoses/tubes on both ends.
Rs. 3000/- per occasion.

8. No fencing/barricading of excavated areas /trenches.
Rs. 3000/- per occasion.

9. Not providing shoring/strutting/proper slope and not keeping the excavated earth at least 1.5M away from excavated area.
Rs.5,000/- per occasion.

10. Non display of scaffold tags, caution boards, list of hospitals, emergency services available at work locations.
Rs.1000/- per occasion per day

11. Traffic rules violations like over speeding of vehicles, rash driving, talking on mobile phones during vehicle driving, wrong parking, not using seat belts, vehicles not fitted with reverse horn / warning alarms / flicker lamps during foggy weather.
Rs. 2000/- per occasion per day

12. Absence of Contractor's RCM/SIC or his nominated representative (prior approval must be taken for each meeting for nomination) from site HSE meetings whenever called by Consultant/Owner & failure to nominate his immediate deputy (in the site organ gram) for such HSE meetings.
Rs10000/- per meeting.

13. Failure to maintain HSE records by Contractor Safety personnel, in line with approved HSE Plan/Procedures/Contract specifications.
Rs 10000/- per month.
14. Failure to conduct daily site safety inspection (by Contractor’s safety engineers/safety officers), internal HSE meeting, internal HSE Awareness/Motivation Program, Site HSE Training and HSE audit at predefined frequencies (as approved in HSE Plan).
Rs.10000/- per occasion.
15. Failure to submit the monthly HSE report by 5th of subsequent month to Project’s Engineer-in-Charge /Owner
Rs. 10000/- per occasion and Rs.1000/- per day of further delay.
16. Poor House Keeping Rs. 5000/- per occasion per subject
17. Failure to report & follow up accident (including Near Miss) reporting system within specific timeframe.
Rs. 20000/- per occasion
18. Degradation of environment (not confining toxic spills, spilling oil/lubricants onto ground).
Rs10000/- per occasion
19. Not medically examining the workers before allowing them to work at height / to work in confined space / to work in shot-blasting / to work for painting / to work in bitumen or asphalt works, not providing ear muffs while allowing them to work in noise polluted areas, made them to work in air polluted areas without respiratory protective devices, etc.
Rs 5000/- per occasion per worker
20. Violation of any other safety condition as per job HSE plan / work permit and HSE conditions of contract (e.g. using crowbar on cable trenches, improper welding booth, not keeping fire extinguisher ready at hot work site, unsafe rigging practices, non-availability of First-Aid box at site, not using hood with respiratory devices by blaster for shot//grit blasting, etc.)
Rs. 5000/- per occasion
21. Failure to carry-out Safety audit in time (internal & external), close-out of identified shortfalls of Observations of Safety Aspects(OSA), etc
Rs. 20,000/- per occasion
22. Carrying out sand blasting instead of grit/shot blasting
Rs. 50,000/- per day
23. Failure to deploy adequately qualified and competent Safety Officer
Rs. 10000/- per day per Officer
24. Utilization of hydra/ back-hoe loader for material shifting or any other unauthorized /unsafe lifting works
Rs 25,000/- per occasion

25. Any violation not covered above to be decided by Consultant/Owner.

26. Any physical injury - maximum of Rs.2,00,000 per injury

27. Fatal accident - Rs. 25,00,000 per fatality

Note:- This penalty shall be in addition to all other penalties specified elsewhere in the contract. The decision of imposing stop-work instruction and imposition of work penalty shall rest with PDIL/Owner. The same shall be binding by the contractor. Imposition of penalty does not make the contractor eligible to continue the work in unsafe manner.
SECTION : VI - 15.0

VENDOR LIST

PLANT : STEAM GENERATION PLANT

PROJECT : INTEGRATED COAL BASED FERTILISER COMPLEX, AT TALCHER, ANGUL DISTRICT, ODISHA
<table>
<thead>
<tr>
<th>SECTION NUMBER</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Process</td>
</tr>
<tr>
<td>2.0</td>
<td>Static Equipments</td>
</tr>
<tr>
<td>3.0</td>
<td>Rotating Equipments</td>
</tr>
<tr>
<td>4.0</td>
<td>Electrical</td>
</tr>
<tr>
<td>5.0</td>
<td>Civil</td>
</tr>
<tr>
<td>6.0</td>
<td>Material Handling</td>
</tr>
<tr>
<td>7.0</td>
<td>Instrumentation</td>
</tr>
<tr>
<td>8.0</td>
<td>Piping</td>
</tr>
</tbody>
</table>
Bidder shall select sub vendors from the vendor list as specified below. Bidder shall ensure that sub vendor for the specified item has supplied item for the specified service & the supplied item is in satisfactory service since last 3 years as on date of offer.

Vendor shall have well proven record for the specified services and shall be subjected to owner/consultant approval.

1.0 **PROCESS:**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Vendor’s Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>SudChemie</td>
<td>India/ Germany</td>
</tr>
<tr>
<td>2.</td>
<td>Johnson Matthey</td>
<td>India/ U.S.A</td>
</tr>
</tbody>
</table>

**Activated Carbon**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Vendor’s Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Active carbon India Ltd</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>Industrial Carbon</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>Ion Exchange India Ltd</td>
<td>India</td>
</tr>
<tr>
<td>4.</td>
<td>CarbotechAktivkohlenGmbh</td>
<td>Germany</td>
</tr>
<tr>
<td>5.</td>
<td>ChemViron</td>
<td>Italy</td>
</tr>
<tr>
<td>6.</td>
<td>Calgon Corporation</td>
<td>U.S.A</td>
</tr>
<tr>
<td>7.</td>
<td>Norit</td>
<td>USA/ Netherland</td>
</tr>
</tbody>
</table>

**Oil Water Separation Unit (TPI/ CPI Type Disc Oil)**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Vendor’s Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>BP Limited</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>Hindustan Dorr Oliver Ltd</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>Ion Exchange India Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>4.</td>
<td>K-Pack</td>
<td>India</td>
</tr>
<tr>
<td>5.</td>
<td>Paramount India Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>6.</td>
<td>OCS</td>
<td>Italy</td>
</tr>
</tbody>
</table>

**Pollution Control Equipments**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Vendor’s Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Hindustan Dorr Oliver Ltd</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>OndeoDegremont</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>Paramount India Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>4.</td>
<td>Trema Rja Processes Pvt. Ltd</td>
<td>India</td>
</tr>
</tbody>
</table>

**Vacuum System**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Vendor’s Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>GEA Weigand GMBH</td>
<td>Germany</td>
</tr>
<tr>
<td>2.</td>
<td>Koerting Hannover AG</td>
<td>Germany</td>
</tr>
<tr>
<td>3.</td>
<td>Graham Manufacturing Co. Inc</td>
<td>USA</td>
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2.0 **STATIC EQUIPMENTS:**

<table>
<thead>
<tr>
<th>ITEM DESCRIPTION</th>
<th>Country</th>
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<tbody>
<tr>
<td>VESSELS IN CS/AS/SS PRESSURE UPTO 10 Kg/cm2g</td>
<td></td>
</tr>
<tr>
<td>1 AERO ENGINEERS</td>
<td>INDIA</td>
</tr>
<tr>
<td>2 AIRFRIGE INDUSTRIES</td>
<td>INDIA</td>
</tr>
<tr>
<td>3 ARTSON ENGINEERING LIMITED</td>
<td>INDIA</td>
</tr>
<tr>
<td>4 B H P V</td>
<td>INDIA</td>
</tr>
<tr>
<td>5 BHARAT HEAVY ELECTRICALS LTD.</td>
<td>INDIA</td>
</tr>
<tr>
<td>No.</td>
<td>Company Name</td>
</tr>
<tr>
<td>-----</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>6</td>
<td>FABTECH PROJECTS &amp; ENGINNERS LTD. (For CS Only)</td>
</tr>
<tr>
<td>7</td>
<td>FLOWLINK INDUSTRIES PVT. LTD. (CS/SS Except Urea Service)</td>
</tr>
<tr>
<td>8</td>
<td>FURNACE FABRICA (INDIA) LTD. (CS/SS)</td>
</tr>
<tr>
<td>9</td>
<td>G R ENGINEERING PRIVATE LIMITED</td>
</tr>
<tr>
<td>10</td>
<td>GANSONS LTD.</td>
</tr>
<tr>
<td>11</td>
<td>GEMINI ENGI-FAB PVT. LTD. (Excluding AS Mati)</td>
</tr>
<tr>
<td>12</td>
<td>GHANSHYAM STEEL WORKS LTD. (CS/SS)</td>
</tr>
<tr>
<td>13</td>
<td>GMM PFAUDLER LIMITED</td>
</tr>
<tr>
<td>14</td>
<td>GODREJ &amp; BOYCE MFG. CO. LTD</td>
</tr>
<tr>
<td>15</td>
<td>GRAND PRIX ENGINEERING PVT. LTD. (upto 4m D x 6m L x80mm Thk)</td>
</tr>
<tr>
<td>16</td>
<td>GRASIM INDUSTRIES</td>
</tr>
<tr>
<td>17</td>
<td>HEATEX INDIAN CORPORATION</td>
</tr>
<tr>
<td>18</td>
<td>HINDUSTAN DORR-OLIVER LTD.</td>
</tr>
<tr>
<td>19</td>
<td>ICEM ENGG. CO. LTD.</td>
</tr>
<tr>
<td>20</td>
<td>INDIA TUBE MILLS &amp; METAL INDUSTRIES LTD. (For CS/SS only)</td>
</tr>
<tr>
<td>21</td>
<td>INDUS PROJECTS LTD (FORMERLY INDUS ENGG)</td>
</tr>
<tr>
<td>22</td>
<td>ISHAN EQUIPMENTS PVT. LTD. (CS/SS only)</td>
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<tr>
<td>23</td>
<td>KINETICS TECHNOLOGY INDIA LTD.</td>
</tr>
<tr>
<td>24</td>
<td>LARSEN &amp; TOUBRO LTD.</td>
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<tr>
<td>25</td>
<td>LLOYDS STEEL INDUSTRIES LIMITD</td>
</tr>
<tr>
<td>26</td>
<td>LOYAL EQUIPMENTS PVT. LTD. (CS/SS and Non IBR only)</td>
</tr>
<tr>
<td>27</td>
<td>MARS DESIGN PVT. LTD.</td>
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<tr>
<td>28</td>
<td>MISTRY PRABHUDAS MANJI ENGG. PVT. LTD.</td>
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<tr>
<td>29</td>
<td>MOD FABRICATORS</td>
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<tr>
<td>30</td>
<td>MULTI-MAX ENGINEERING WORKS PVT. LTD. (CS and SS Material only)</td>
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<tr>
<td>31</td>
<td>NAVA BHARAT FERRO ALLOYS LTD</td>
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<tr>
<td>32</td>
<td>NEW FIELD INDUSTRIAL EQUIPMENT PVT. LTD. (CS/SS Only)</td>
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<tr>
<td>33</td>
<td>NIVITA ENGINEERING WORKS</td>
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<tr>
<td>34</td>
<td>NOVATECH PROJECTS INDIA (P) LTD. (CS and SS material only)</td>
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<tr>
<td>35</td>
<td>ORIENTAL MANUFACTURERS PROVATE LIMITED (CS/SS only)</td>
</tr>
<tr>
<td>36</td>
<td>PATELS AIRTEM (INDIA LIMITED)</td>
</tr>
<tr>
<td>37</td>
<td>PRECISION EQUIPMENTS (CHAANAI) PVT LTD</td>
</tr>
<tr>
<td>38</td>
<td>PROJECT TECHNOLOGISTS PVT. LTD.</td>
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<tr>
<td>39</td>
<td>R.D. ENGINEERS (INDIA) PVT. LTD.</td>
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<tr>
<td>40</td>
<td>RAJ ENGG. CO.</td>
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<td>41</td>
<td>RELIANCE FABRICATIONS PVT. LTD.</td>
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<td>42</td>
<td>REYNOLDS CHEMEQUIP PRIVATE LIMITED (CS/SS)</td>
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<tr>
<td>43</td>
<td>SHRENO LTD. (UNIT 2)</td>
</tr>
<tr>
<td>No.</td>
<td>Company Name</td>
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<tr>
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<tr>
<td>44</td>
<td>TAS ENGINEERING CO. (P) LIMITED</td>
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<tr>
<td>45</td>
<td>TATA CHEMICALS LTD</td>
</tr>
<tr>
<td>46</td>
<td>THE ANUP ENGINEERING LIMITED</td>
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<tr>
<td>47</td>
<td>THE INDIAN SUGAR &amp; GENERAL ENGG. CORPN.</td>
</tr>
<tr>
<td></td>
<td>(ISGEC), YAMUNA NGR</td>
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<tr>
<td>48</td>
<td>TITANIUM EQUIPMENT AND ANODE MFG. CO. LTD.</td>
</tr>
<tr>
<td>49</td>
<td>TRIVENI STRUCTURALS LTD.</td>
</tr>
<tr>
<td>50</td>
<td>UNITOP ENGINEERS PVT. LTD. (Max. Shell Dia 4.65, Water vol. 140m3)</td>
</tr>
<tr>
<td>51</td>
<td>HYOSUNG CORPORATION (CS/SS/LAS only)</td>
</tr>
<tr>
<td>52</td>
<td>APPARATEBAU SCHWEISS TECHNIK GMBH</td>
</tr>
<tr>
<td>53</td>
<td>SCHOELLER-BLECKMANN NITEC GMBH</td>
</tr>
<tr>
<td>54</td>
<td>OLMI SPA</td>
</tr>
<tr>
<td>55</td>
<td>JAPAN STEEL WORKS LTD</td>
</tr>
<tr>
<td>56</td>
<td>DOOSAN MECATEC CO. LTD.</td>
</tr>
<tr>
<td>57</td>
<td>HANJUNG DCM CO. LTD.</td>
</tr>
<tr>
<td>58</td>
<td>HUNDAI HEAVY INDUSTRIES</td>
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<tr>
<td>59</td>
<td>KOREA HEAVY INDUSTRIES &amp; CONSTN. CO. LTD</td>
</tr>
<tr>
<td>60</td>
<td>CHEM PROCESS SYETEM PVT. LTD. (CS/SS ONLY)</td>
</tr>
<tr>
<td>61</td>
<td>COPERION IDEAL PVT. LTD.</td>
</tr>
<tr>
<td>62</td>
<td>ESSAR HEAHY ENGINEERING SERVICES</td>
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<tr>
<td>63</td>
<td>PHILS HEAVY ENGINEERIG PVT. LTD.</td>
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<td>64</td>
<td>PRAJ INDUSTRIES LIMITED</td>
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<td>65</td>
<td>SPETECH PLANT EQUIPMENT PVT. LTD. (CS ONLY)</td>
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<tr>
<td>66</td>
<td>TECHNO PROCESS EQUIPMENT (I) LTD. (CS/AS/SS(AS only for P3 Material))</td>
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<tr>
<td>67</td>
<td>UNIVERSAL HEAT EXCHANGER LIMITED (CS/SS/LTCS only)</td>
</tr>
<tr>
<td>68</td>
<td>VIJAY TANKS &amp; VESSELS LIMITED (CS/LAS AND SS ONLY)</td>
</tr>
<tr>
<td>69</td>
<td>VIJAY TANKS &amp; VESSELS LIMITED (KANDLA) (CS/ SS ONLY)</td>
</tr>
<tr>
<td>70</td>
<td>SUNGJIN GEOTECH CO. LTD. (CS and SS only)</td>
</tr>
</tbody>
</table>

**VESSELS IN CS/AS/SS PRESSURE 11 TO 60 Kg/cm2g**

<table>
<thead>
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<th>No.</th>
<th>Company Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ALTECH INFRASTRUCTURE (INDIA) PVT. LTD. (Upto 20 Kg/cm2(g)CS Material)</td>
<td>INDIA</td>
</tr>
<tr>
<td>2</td>
<td>ARIEN NEW DELHI PRIVATE LIMITED (CS/SS UP TO 11 to 30 Kg/cm2(g))</td>
<td>INDIA</td>
</tr>
<tr>
<td>3</td>
<td>B H P V</td>
<td>INDIA</td>
</tr>
<tr>
<td>4</td>
<td>BHARAT HEAVY ELECTRICALS LTD.</td>
<td>INDIA</td>
</tr>
<tr>
<td>5</td>
<td>EXPO GAS CONTAINERS LTD. (Upto 30 Kg/sq cm (g) CS/SS Material.)</td>
<td>INDIA</td>
</tr>
<tr>
<td>6</td>
<td>FABTECH PROJECTS &amp; ENGINNERS LTD. (For CS Only)</td>
<td>INDIA</td>
</tr>
<tr>
<td>7</td>
<td>FURNACE FABRICA (INDIA) LTD. (CS/SS UP TO 11 to 30)</td>
<td>INDIA</td>
</tr>
<tr>
<td>Number</td>
<td>Vendor Name</td>
<td>Country</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------------------------------------</td>
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</tr>
<tr>
<td>8</td>
<td>G R ENGINEERING PRIVATE LIMITED</td>
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</tr>
<tr>
<td>9</td>
<td>GANSONS LTD.</td>
<td>INDIA</td>
</tr>
<tr>
<td>10</td>
<td>GHANSHYAM STEEL WORKS LTD (CS/SS)</td>
<td>INDIA</td>
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<tr>
<td>11</td>
<td>GODREJ &amp; BOYCE MFG. CO. LTD</td>
<td>INDIA</td>
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<tr>
<td>12</td>
<td>GRAND PRIX ENGINEERING PVT. LTD.</td>
<td>INDIA</td>
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<tr>
<td>13</td>
<td>GRASIM INDUSTRIES (upto 30Kg/cm2g)</td>
<td>INDIA</td>
</tr>
<tr>
<td>14</td>
<td>HEATEX INDIAN CORPORATION</td>
<td>INDIA</td>
</tr>
<tr>
<td>15</td>
<td>INDUSTAN DORR-OLIVER LTD. (CS/SS Only)</td>
<td>INDIA</td>
</tr>
<tr>
<td>16</td>
<td>INDIA TUBE MILLS &amp; METAL INDUSTRIES LTD. (For CS/SS only upto 30 Kg/cm2g)</td>
<td>INDIA</td>
</tr>
<tr>
<td>17</td>
<td>INDUS PROJECTS LTD (FORMERLY INDUS ENGG)</td>
<td>INDIA</td>
</tr>
<tr>
<td>18</td>
<td>ISHAN EQUIPMENTS PVT. LTD. (CS/SS Upto 30 Kg/Cm2(g) only)</td>
<td>INDIA</td>
</tr>
<tr>
<td>19</td>
<td>KAVERI ENGG. INDUSTRIES LTD.</td>
<td>INDIA</td>
</tr>
<tr>
<td>20</td>
<td>LARSEN &amp; TOUBRO LTD</td>
<td>INDIA</td>
</tr>
<tr>
<td>21</td>
<td>LLOYDS STEEL INDUSTRIES LIMITED</td>
<td>INDIA</td>
</tr>
<tr>
<td>22</td>
<td>LOYAL EQUIPMENTS PVT. LTD. (Upto 11-30 Kg/cm2, CS/SS and Non IBR only.)</td>
<td>INDIA</td>
</tr>
<tr>
<td>23</td>
<td>MULTI-MAX ENGINEERING WORKS PVT. LTD. (Up to 30 Kg/cm2g (CS and SS Materials only)</td>
<td>INDIA</td>
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<tr>
<td>24</td>
<td>NEW FIELF INDUSTRIAL EQUIPMENT PVT. LTD. (Upto 30 Kg/cm2g (CS/SS Only)</td>
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<tr>
<td>25</td>
<td>ORIENTAL MANUFACTURERS PRIVATE LIMITED (CS/SS only)</td>
<td>INDIA</td>
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<tr>
<td>26</td>
<td>PATELS AIRTEMP (INDIA LIMITED (CS &amp; SS only)</td>
<td>INDIA</td>
</tr>
<tr>
<td>27</td>
<td>PRECISION EQUIPMENTS (CHENNAI) PVT. LTD (upto 30Kg/cm2g)</td>
<td>INDIA</td>
</tr>
<tr>
<td>28</td>
<td>RAJ ENG. CO. (up to 30kg/cm 2 (g) CS/SS/AS (P3 &amp; P4 only)</td>
<td>INDIA</td>
</tr>
<tr>
<td>29</td>
<td>THE ANUP ENGINEERING LIMITED</td>
<td>INDIA</td>
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<tr>
<td>30</td>
<td>THE INDIAN SUGAR &amp; GENERAL ENGG. CORPN. (ISGEC), DAHEJ (Except Urea Plant Critical Equipment)</td>
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<tr>
<td>31</td>
<td>THE INDIAN SUGAR &amp; GENERAL ENGG. CORPN. (ISGEC), YAMUNA NGR</td>
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<td>32</td>
<td>HYOSUNG CORPORATION (CS/SS/LAS only)</td>
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<td>AUSTRIA</td>
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<td>BORSING GmbH</td>
<td>GERMANY</td>
</tr>
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<td>BELLELI S.P.A</td>
<td>ITALY</td>
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<td>FBM HUDSON ITALIANA S.p.A</td>
<td>ITALY</td>
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<tr>
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<td>GE POWER (NUOVO PIGNONE SPA)</td>
<td>ITALY</td>
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<tr>
<td>38</td>
<td>ROLLE S.P.A. (11 TO 60 kg/cm2 pr.)</td>
<td>ITALY</td>
</tr>
<tr>
<td>39</td>
<td>WALTER TOSTO SpA</td>
<td>ITALY</td>
</tr>
<tr>
<td>40</td>
<td>HITACHI ZOSEN</td>
<td>JAPAN</td>
</tr>
<tr>
<td>41</td>
<td>KOBE STEEL LIMITED</td>
<td>JAPAN</td>
</tr>
<tr>
<td>No.</td>
<td>Vendor Name</td>
<td>Country</td>
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<tr>
<td>42</td>
<td>MITSUBISHI HEAVY INDUSTRIES LTD.</td>
<td>JAPAN</td>
</tr>
<tr>
<td>43</td>
<td>MITSUI ENGINEERING &amp; SHIPBUILDING CO. LTD</td>
<td>JAPAN</td>
</tr>
<tr>
<td>44</td>
<td>DOOSAN MECATEC CO. LTD.</td>
<td>KOREA</td>
</tr>
<tr>
<td>45</td>
<td>HANJUNG DCM CO. LTD.</td>
<td>KOREA</td>
</tr>
<tr>
<td>46</td>
<td>HANTECH LIMITED</td>
<td>KOREA</td>
</tr>
<tr>
<td>47</td>
<td>KOREA HEAVE INDUSTRIES &amp; CONSN. CO. LTD</td>
<td>KOREA</td>
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<td>MECANICA DE LA PENA S.A.</td>
<td>SPAIN</td>
</tr>
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<td>49</td>
<td>BEAIRD INDUSTRIES LOUISIANA</td>
<td>U.S.A</td>
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<td>50</td>
<td>CHEM PROCESS SYSTEM PVT. LTD. (CS/SS upto 30</td>
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<td>kg/cm²g only)</td>
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<td>CICB-CHEMICON PVT. LTD. (upto 30 kg/cm²2 only</td>
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<td>(CS only ))</td>
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<td>53</td>
<td>FAB-TECH WORKS &amp; CONSTRUCTIONS PRIVATE LIMITED</td>
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<td>LTCS/SS only upto 30 kg/cm²2g)</td>
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<td>upto 30 kg/cm²2g (AS only for P3 Material))</td>
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<td>VIJYA TANKS &amp; VESSELS LIMITED (CS/SS and LAS</td>
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<td>VIJYA TANKS &amp; VESSELS LIMITED (KANDLA)(CS/SS</td>
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**VESSELS IN CS/AS/SS PRESSURE ABOVE 60 Kg/cm²2g**

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<td>HYOSUNG CORPORATION (CS/SS/LAS only)</td>
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<td>SUMISHO MACHINERY TRADE CORPORATION</td>
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<td>SCHOELLER-BLECKMANN NITEC GMBH</td>
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<td>HINDUSTAN DORR-OLIVER LTD. (CS/SS/LAS/LTCS only)</td>
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<td>SUNGJIN GEOTEC CO. LTD. (CS and SS only)</td>
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### SMALL COLUMNS

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<td>FOSTER WHEELER POWER PRODUCTS LTD</td>
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**SHOP FABRICATED TANKS & NONCODED VESSELS**

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<td>FLOWLINK INDUSTRIES PVT. LTD. (CS/SS only)</td>
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**Storage Tanks (Site Fabricated)**

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**Trays, Distributors & Internals**

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**DEMISTERS**

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**HEAT EXCHANGERS UPTO 30 Kg/cm2g**

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**HEAT EXCHANGERS 30 TO 60 kg/cm2G**

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**HEAT EXCHANGERS ABOVE 60 Kgcm²g**

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**EXCHANGERS AIRCOOLED / FINNED TYPE**

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**PLATE TYPE HEAT EXCHANGERS**

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**FRP / PVC TANKS & VESSELS**

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<td>APPARATEBAU SCHWEISSTECHNIK GMBH (acid)</td>
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storage tanks upto 3.8 in dia.

### FRP / PVC LINING

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### 3.0 ROTATING EQUIPMENTS:

#### PUMPS FOR HP BFW SERVICE (ABOVE 60 KG/CM2 DISCHARGE PRESSURE)

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#### PUMPS FOR CRITICAL PROCESS

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<tr>
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<tr>
<td>13</td>
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#### PUMPS FOR CHEMICALS/ ACID/ ALKALI/ BFW/ CONDENSATE USE

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**COOLING WATER PUMPS (HORIZONTAL)**

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**COOLING WATER PUMPS (VERTICAL)**

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**PUMPS FOR SLURRY SERVICE**

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**PUMPS FOR UTILITY SERVICES**
### STEAM GENERATION PLANT
### TALCHER FERTILIZERS LIMITED
### VENDOR LIST

**PC150/E/4003/SecVI-15.0**

**Document No.** Rev
**Sheet 19 of 88**

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**CENTRIFUGAL MONOBLOCK PUMP SET**

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<td>5. PRECISION ENGINEERING INDUSTRIES (SMALL PUMPS UPTO 2 HP)</td>
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**SUMP PUMPS**

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**PUMPS FOR CHEMICAL DOSING/ METERING**

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<td>3. MILTON ROY INDIA (P) LTD</td>
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**PUMPS FOR MISC. NON CRITICAL SERVICE (RECIPROCATING TYPE)**

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<th>Vendor</th>
<th>Country</th>
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<tbody>
<tr>
<td>1. A.R WILFLEY INDIA PVT. LTD</td>
<td>INDIA</td>
</tr>
<tr>
<td>2. KSB PUMPS LTD.</td>
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<tr>
<td>3. SULZER PUMPS INDIA LTD</td>
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<tr>
<td>4. V.K PUMPS INDUSTRIES PVT. LTD</td>
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</tr>
<tr>
<td>5. UT PUMPS &amp; SYSTEM PVT. LTD.</td>
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</tr>
<tr>
<td>6. LEWA HERBERTOTT GMBH &amp; CO</td>
<td>GERMANY</td>
</tr>
<tr>
<td>7. URACA PUMPENFABRIK GMBH &amp; CO</td>
<td>GERMANY</td>
</tr>
<tr>
<td>Vendor</td>
<td>Country</td>
</tr>
<tr>
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<td>---------</td>
</tr>
<tr>
<td>DOSAPRO MILLTON ROY</td>
<td>ITALY</td>
</tr>
<tr>
<td>9. PERONI POMPE SPA (CAPACITY = 95 M3/HR, PRE = 306 KG/CM2)</td>
<td>ITALY</td>
</tr>
<tr>
<td>10. NIGATA WORTHINGTON PUMPS</td>
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<tr>
<td>11. NIKKISO CO. LTD.</td>
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</tr>
<tr>
<td>12. BRAN &amp; LUEBBE LTD.</td>
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### ROTARY PUMPS AND SCREW PUMPS

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<tbody>
<tr>
<td>1. AIAUTO INDUSTRIES</td>
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<tr>
<td>2. DELTA CORPORATION</td>
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<tr>
<td>3. ROTO PUMPS LTD</td>
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<tr>
<td>4. UT PUMPS AND SYSTEMS LTD</td>
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### CENTRIFUGAL COMPRESSOR FOR INSTRUMENT/ SERVICE AIR SERVICES

<table>
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<tbody>
<tr>
<td>1. INGERSOLL RAND INDIA LTD.</td>
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<tr>
<td>2. ATLAS COPCO ENERGAS GMBH</td>
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</tr>
<tr>
<td>3. GHH BORSIG TURBOMASCHINEN AG</td>
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</tr>
<tr>
<td>4. LINDE AG WERKSGRUPPE</td>
<td>GERMANY</td>
</tr>
<tr>
<td>5. MANNESMAN DEMAG AG</td>
<td>GERMANY</td>
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<tr>
<td>6. SIEMENS AG PGI</td>
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</tr>
<tr>
<td>7. GE POWER (FORMERLY NUOVO PIGNONE SPA)</td>
<td>ITALY</td>
</tr>
<tr>
<td>8. EBARA CORPORATION</td>
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<tr>
<td>9. HITACHI LTD</td>
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<tr>
<td>10. KAWASAKI HEAVY INDUSTRIES LTD.</td>
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</tr>
<tr>
<td>11. KOBE STEEL LTD.</td>
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<tr>
<td>12. MITSUBISHI HEAVY INDUSTRIES LTD.</td>
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<tr>
<td>13. MITSUI ENGINEERING &amp; SHIP BUILDING CO. LTD</td>
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<tr>
<td>14. SULZER TURBO LIMITED</td>
<td>SWITZERLAND</td>
</tr>
<tr>
<td>15. DRESSER-RAND CO.</td>
<td>SINGAPORE</td>
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<tr>
<td>16. ELLIOT OVERSEAS CORPORATION</td>
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### RECIPROCATING COMPRESSOR FOR INSTRUMENT/ SERVICE AIR SERVICES

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<tr>
<td>3. KIRLOSKAR PNEUMATIC CO. LTD</td>
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### SCREW COMPRESSOR FOR INSTRUMENT/ SERVICE AIR SERVICES

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<td>2. MAN TURBOMASCHINEN AG GHH BORSIG</td>
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<tr>
<td>4. SULZER TURBO LIMITED</td>
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<td>5. HOWDEN SIROCCO LIMITED</td>
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### STEAM TURBINE UPTO 3 MW

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<tr>
<td>1. ASEÃ BROWN BOVERI LIMITED</td>
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<tr>
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<tr>
<td>3. TRIVENI ENGG. WORKS LIMITED</td>
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<tr>
<td>4. KIRLOSKAR EBARA PUMPS LIMITED (KEPL)</td>
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<tr>
<td>5. ABB TURBINEN NUMBERG GMBH</td>
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<tr>
<td>6. ALSTOM POWER TURBINEN GMBH</td>
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<td>7. ALTHOM POWER</td>
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<tr>
<td>No.</td>
<td>Vendor Name</td>
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<td>8.</td>
<td>GHH BORSIG TURBOMASCHINEN GMBH</td>
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<tr>
<td>9.</td>
<td>SIEMENS AKTIENGESELLSCHAFT</td>
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<tr>
<td>10.</td>
<td>TUTHILL NADROWSKI TURBINE GMBH</td>
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<tr>
<td>11.</td>
<td>GE POWER (NUOVO PIGNONE SPA)</td>
</tr>
<tr>
<td>12.</td>
<td>EBARA CORPORATION</td>
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<tr>
<td>13.</td>
<td>KAWASAKI HEAVY INDUSTRIES LTD.</td>
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<tr>
<td>14.</td>
<td>MITSUBISHI HEAVY INDUSTRIES LTD.</td>
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<tr>
<td>15.</td>
<td>MITSUI ENGINEERING &amp; SHIP BUILDING CO. LTD</td>
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<td>16.</td>
<td>SHIN NIPPON MACHINERY CO. LTD</td>
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<td>17.</td>
<td>DRESSER RAND CO.</td>
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<td>18.</td>
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<tr>
<td>19.</td>
<td>TRANSMERICA DELAVAL INC.</td>
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<tr>
<td>20.</td>
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### STEAM TURBINE ABOVE 3 MW

<table>
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<tr>
<td>3.</td>
<td>ALSTOM POWER TURBINE GMBH</td>
<td>GERMANY</td>
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<td>4.</td>
<td>GHH BORSIG TURBOMASCHINEN GMBH</td>
<td>GERMANY</td>
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<tr>
<td>5.</td>
<td>SIEMENS AKTIENGESELLSCHAFT</td>
<td>GERMANY</td>
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<tr>
<td>6.</td>
<td>GE POWER (NUOVO PIGNONE SPA)</td>
<td>ITALY</td>
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<td>7.</td>
<td>EBARA CORPORATION</td>
<td>JAPAN</td>
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<td>8.</td>
<td>FUJI ELECTRIC SYSTEMS CO. LTD.</td>
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<td>9.</td>
<td>KAWASAKI HEAVY INDUSTRIES LTD.</td>
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<td>MITSUBISHI HEAVY INDUSTRIES LTD.</td>
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<tr>
<td>11.</td>
<td>MITSUI ENGINEERING &amp; SHIP BUILDING CO. LTD</td>
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<td>12.</td>
<td>ASEA BROWN BOVERI</td>
<td>SWEDEN</td>
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<td>13.</td>
<td>DRESSER RAND CO.</td>
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<td>ELLIOT OVERSEAS CORPORATION</td>
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<td>15.</td>
<td>TRANSMERICA DELAVAL INC.</td>
<td>U.S.A</td>
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<td>16.</td>
<td>TUTHILL ENERGY SYSTEMS</td>
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### FANS & BLOWERS

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<th>Vendor Name</th>
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<td>1.</td>
<td>ABB FLAKT INDIA LTD.</td>
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<td>AEROTO BOLDROCCHI INDIA PVT. LTD.</td>
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<td>3.</td>
<td>AEROVENT PROJECT PVT LTD</td>
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<td>4.</td>
<td>DRAFT INDIA PVT LTD</td>
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<td>5.</td>
<td>MAX FLOW FANS MANUFACTURING PVT LTD</td>
<td>INDIA</td>
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<td>6.</td>
<td>SWAM PNEUMATICS</td>
<td>INDIA</td>
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<td>7.</td>
<td>BHEL</td>
<td>INDIA</td>
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<td>8.</td>
<td>TLT ENGINEERING INDIA PVT. LTD</td>
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<tr>
<td>9.</td>
<td>ILLINOIS BLOWERS INC</td>
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### AGITATORS/ MIXERS

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<th>Vendor Name</th>
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<tr>
<td>1.</td>
<td>GANSONS LTD.</td>
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<td>2.</td>
<td>HYTEC GRANT INSTRUMENTS</td>
<td>INDIA</td>
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<td>3.</td>
<td>MARS DYE CHEM PVT. LTD</td>
<td>INDIA</td>
</tr>
<tr>
<td>Filter &amp; Separators</td>
<td>Company Name</td>
<td>Country</td>
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<tr>
<td>---------------------</td>
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<tr>
<td>1.</td>
<td>Coperion Ideal Pvt. Ltd.</td>
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<td>2.</td>
<td>Fil Sep Equipments Pvt Ltd</td>
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<td>3.</td>
<td>Filtration Engineers Pvt. Ltd</td>
<td>India</td>
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<tr>
<td>4.</td>
<td>Gansons Ltd.</td>
<td>India</td>
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<tr>
<td>5.</td>
<td>Grand Prix Fab (P) Ltd. (Cartridge filters up to 1500#, 40” size)</td>
<td>India</td>
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<tr>
<td>6.</td>
<td>Haver Standard India Pvt. Ltd</td>
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<tr>
<td>7.</td>
<td>Multitex Filtration Engineers Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>8.</td>
<td>Otoklin Plants &amp; Equipment Ltd.</td>
<td>India</td>
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<tr>
<td>9.</td>
<td>Superflo Filters Pvt. Ltd.</td>
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<tr>
<td>10.</td>
<td>Ultra Filter (India) Pvt. Ltd</td>
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<tr>
<td>11.</td>
<td>Peerless Mfg. Company</td>
<td>Singapore</td>
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<td>12.</td>
<td>Watson Process System (for Vane Type Separators)</td>
<td>Canada</td>
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<tr>
<td>13.</td>
<td>Mura Chemicals Equipment Co. Ltd (for Vane Type Separators)</td>
<td>Japan</td>
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<td>14.</td>
<td>Rauscheri Verfahrenstechnik Gmbh</td>
<td>Germany</td>
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<tr>
<td>15.</td>
<td>Northeast Controls Equipment Co. Ltd (for Vane Type Separators)</td>
<td>U.S.A</td>
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<table>
<thead>
<tr>
<th>Process Ejectors</th>
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<tr>
<td>1.</td>
<td>Wiegand India Pvt. Ltd</td>
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<tr>
<td>2.</td>
<td>New Field Industrial Equipment Pvt. Ltd</td>
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<tr>
<td>3.</td>
<td>GEA Jet Pumps Gmbh</td>
<td>Germany</td>
</tr>
<tr>
<td>4.</td>
<td>Korting Hannover Ag</td>
<td>Germany</td>
</tr>
<tr>
<td>5.</td>
<td>Graham Corp.</td>
<td>U.S.A</td>
</tr>
<tr>
<td>6.</td>
<td>Ketema Inc. Schutte &amp; Koerting Division</td>
<td>U.S.A</td>
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<table>
<thead>
<tr>
<th>Gear Box</th>
<th>Company Name</th>
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<tr>
<td>1.</td>
<td>Lufkin- France S.A</td>
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<tr>
<td>2.</td>
<td>Flennder Graffenstaden</td>
<td>France</td>
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<tr>
<td>3.</td>
<td>Voith Turbo BHS - Getriebe Gmbh</td>
<td>Germany</td>
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<td>4.</td>
<td>Renk Aktiengesellschaft</td>
<td>Germany</td>
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<tr>
<td>5.</td>
<td>The Timken Company</td>
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<table>
<thead>
<tr>
<th>Couplings (for BFW Pumps)</th>
<th>Company Name</th>
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<tbody>
<tr>
<td>1.</td>
<td>Euroflex Transmissions</td>
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<tr>
<td>2.</td>
<td>Bibby Turboflex</td>
<td>UK</td>
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<tr>
<td>3.</td>
<td>Eagle Industries Co.Ltd (Ekk)</td>
<td>Japan</td>
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<td>4.</td>
<td>Voith Turbo</td>
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<td>5.</td>
<td>KOP-Flex</td>
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</table>
## COUPLINGS (miscellaneous non critical equipment)

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<tbody>
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<td>ELECON ENGG. CO. LTD</td>
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<td>2.</td>
<td>FENNER INDIA LTD.</td>
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<td>3.</td>
<td>HI-CLIFF</td>
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<td>4.</td>
<td>RATHI TRANSPower PVT. LTD</td>
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<td>5.</td>
<td>RATHI TURBOFLEX PVT. LTD</td>
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## ARC VALVES

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<tbody>
<tr>
<td>1.</td>
<td>HOLTHER REGELARMETUREN GMBH &amp; CO. KG (HORA)</td>
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<td>2.</td>
<td>SCHROEDAHNL</td>
<td>GERMANY</td>
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<td>SCHROEDER</td>
<td>GERMANY</td>
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<tr>
<td>4.</td>
<td>YARWAY CORPORATION (FORMERLY TYCO ENGINEERING &amp; CONSTRUCTION PVT. LTD)</td>
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## AIR CONDITIONING SYSTEM

### MAKE OF CHILLER UNIT / AC PACKAGE:

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<tr>
<td>2.</td>
<td>TRANE</td>
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<tr>
<td>3.</td>
<td>CARRIER</td>
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<td>4.</td>
<td>BLUE STAR</td>
<td>INDIA</td>
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<tr>
<td>5.</td>
<td>VOLTAS</td>
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## AIR CONDITIONING SYSTEM (EPC VENDORS)

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<td>3.</td>
<td>ADVANCE VENTILATION PVT LTD</td>
<td>INDIA</td>
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<tr>
<td>4.</td>
<td>VERTIV ENERGY PRIVATE LIMITED</td>
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<tr>
<td>5.</td>
<td>S K SYSTEMS PVT LTD</td>
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### ELECTRICAL:

#### Paging Equipment / Public Address System

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<tr>
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<td>Crompton Greaves Ltd</td>
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<td>2.</td>
<td>Hakotronics Private Limited</td>
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<tr>
<td>3.</td>
<td>Indian Telephone Industries Ltd.</td>
<td>India</td>
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<td>4.</td>
<td>Philips India Ltd.</td>
<td>India</td>
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<tr>
<td>5.</td>
<td>Tata Telecom Limited</td>
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<tr>
<td>6.</td>
<td>Telemax Corporation</td>
<td>India</td>
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<tr>
<td>7.</td>
<td>Neumann Gmbh Elektronik</td>
<td>Germany</td>
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<tr>
<td>8.</td>
<td>Motorola Singapore PTE Ltd.</td>
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### UPS System

<table>
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<tr>
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<td>VERTIV Energy Private Limited* (formally known as Emerson Network Power (India) Pvt. Ltd)</td>
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<td>2</td>
<td>GE Power Controls India Pvt. Ltd</td>
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<tr>
<td>3</td>
<td>AEG Telefunken AG.</td>
<td>Germany</td>
</tr>
<tr>
<td>4</td>
<td>Asea Brown Boveri</td>
<td>Sweden</td>
</tr>
<tr>
<td>5</td>
<td>General Electric Co.</td>
<td>U.S.A.</td>
</tr>
<tr>
<td>6</td>
<td>Westinghouse Electric Corporation</td>
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</tr>
<tr>
<td>7</td>
<td>PILLER [PCI LTD</td>
<td>GERMANY</td>
</tr>
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<td></td>
<td></td>
<td>[INDIA]</td>
</tr>
<tr>
<td>8</td>
<td>GUTOR</td>
<td>GERMANY</td>
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### Transformers – 33 kV & Below

<table>
<thead>
<tr>
<th>No.</th>
<th>Vendor Name</th>
<th>Country</th>
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<tbody>
<tr>
<td>1</td>
<td>Alstom Limited ( Areva T &amp; D)</td>
<td>India</td>
</tr>
<tr>
<td>2</td>
<td>Crompton Greaves Ltd</td>
<td>India</td>
</tr>
<tr>
<td>3</td>
<td>Emco Limited</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>Bharat Bijlee Ltd</td>
<td>India</td>
</tr>
<tr>
<td>5</td>
<td>Kirloskar Electric Company Ltd.</td>
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</tr>
<tr>
<td>6</td>
<td>Voltamp Transformers Ltd.</td>
<td>India</td>
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</table>

### Auxiliary Supply Transformers

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<tr>
<th>No.</th>
<th>Vendor Name</th>
<th>Country</th>
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<tbody>
<tr>
<td>1</td>
<td>Esennar Transformers (P) Ltd.</td>
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</tr>
<tr>
<td>2</td>
<td>Gujarat Plug-In Devices Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>3</td>
<td>IMP Power Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>Indcoil Transformers Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>5</td>
<td>Kalpa Electrical Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>6</td>
<td>Mehru Electricals (Formerly Automatic Electric Limited)</td>
<td>India</td>
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<tr>
<td>7</td>
<td>Shephard Transformers Ltd.</td>
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<tr>
<td>8</td>
<td>Vardhman Electro-mech Pvt. Ltd.</td>
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</table>

### Neutral Earthing Resistor

<table>
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<tr>
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<th>Vendor Name</th>
<th>Country</th>
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<tbody>
<tr>
<td>1</td>
<td>Elecmech Corporation</td>
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</tr>
<tr>
<td>2</td>
<td>Lotus Powergear Pvt Ltd</td>
<td>India</td>
</tr>
<tr>
<td>3</td>
<td>Resitech Electricals Private Limited</td>
<td>India</td>
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<tr>
<td>4</td>
<td>RSI Switchgear Private Ltd.</td>
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<tr>
<td>5</td>
<td>S R Narkhede Engineering Pvt. Ltd.</td>
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### HV Switchboard (11 kV & 3.3 kV)

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<th>No.</th>
<th>Vendor Name</th>
<th>Country</th>
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<tbody>
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<td>1</td>
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<td>India</td>
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<tr>
<td>No.</td>
<td>Company Name</td>
<td>Country</td>
</tr>
<tr>
<td>-----</td>
<td>----------------------------------</td>
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</tr>
<tr>
<td>2.</td>
<td>Crompton Greaves Ltd</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>Siemens Ltd</td>
<td>India</td>
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<tr>
<td>4.</td>
<td>BHEL (Electrical Machines Divn.)</td>
<td>India</td>
</tr>
<tr>
<td>5.</td>
<td>Schneider Electric</td>
<td>India</td>
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</table>

415 V SWITCH BOARD (PCC/MCC/PMCC)

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<tr>
<th>No.</th>
<th>Company Name</th>
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<tr>
<td>1.</td>
<td>Alstom Limited (Areva T &amp; D)</td>
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<tr>
<td>2.</td>
<td>GE Power Controls India Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>Larsen &amp; Toubro Ltd.(El.Products Divn)</td>
<td>India</td>
</tr>
<tr>
<td>4.</td>
<td>Siemens Ltd</td>
<td>India</td>
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<tr>
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Floor Mounting Type Distribution Boards

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<th>Country</th>
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<tbody>
<tr>
<td>1.</td>
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<tr>
<td>2.</td>
<td>Associated Switchgears &amp; Projects Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>Automatic Controls Corporation</td>
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<tr>
<td>4.</td>
<td>Avone System &amp; Controls</td>
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<tr>
<td>5.</td>
<td>Controls &amp; Schematics Pvt Ltd.</td>
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</tr>
<tr>
<td>6.</td>
<td>C &amp; S Electric Ltd</td>
<td>India</td>
</tr>
<tr>
<td>7.</td>
<td>Cosmic Power Systems Pvt. Ltd.</td>
<td>India</td>
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<tr>
<td>8.</td>
<td>Electric Supply &amp; Services (P) Ltd</td>
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</tr>
<tr>
<td>9.</td>
<td>Elecmech Corporation</td>
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<td>10.</td>
<td>GE Power Controls India Pvt. Ltd.</td>
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<tr>
<td>11.</td>
<td>Globe Electrical Industries</td>
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<tr>
<td>12.</td>
<td>Hi-Tech Engineers</td>
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<td>13.</td>
<td>Hindustan Control &amp;Eqpt Pvt. Ltd.</td>
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<tr>
<td>14.</td>
<td>Intrelec</td>
<td>India</td>
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<tr>
<td>15.</td>
<td>Jakson Engineers Ltd</td>
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<td>16.</td>
<td>Jasper Switchgears Limited</td>
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<td>17.</td>
<td>Larsen &amp; Toubro Ltd.(El.Products Divn)</td>
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<td>18.</td>
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<td>19.</td>
<td>Reunion Electrical Manufacturers (P) Ltd</td>
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<td>Shivalic Power Control (P) Ltd.</td>
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<td>22.</td>
<td>Spaceage Switchgears Limited</td>
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<td>23.</td>
<td>Tricolite Electrical Industries Pvt. Ltd.</td>
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<td>24.</td>
<td>Trident Switchgears Pvt. Ltd. (Upto 3200 A)</td>
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<td>25.</td>
<td>United Electric Co. (Delhi) Pvt. Ltd</td>
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<td>26.</td>
<td>Universal Industrial Products</td>
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<td>27.</td>
<td>Venus Controls &amp; Switchgear (P) Ltd.</td>
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<td>28.</td>
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## Wall Mounting Type Distribution Boards

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<tr>
<td>1.</td>
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<tr>
<td>2.</td>
<td>Associated Switchgears &amp; Projects Ltd.</td>
<td>India</td>
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<tr>
<td>3.</td>
<td>C &amp; S Electric Ltd</td>
<td>India</td>
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<td>4.</td>
<td>Cosmic Power Systems Pvt. Ltd.</td>
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<td>5.</td>
<td>Elecmech Corporation</td>
<td>India</td>
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<td>6.</td>
<td>GE Power Controls India Pvt. Ltd.</td>
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<td>India</td>
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<td>8.</td>
<td>Larsen &amp; Toubro Ltd. (El. Products Divn)</td>
<td>India</td>
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<td>9.</td>
<td>Lotus Powergear Pvt Ltd</td>
<td>India</td>
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<td>10.</td>
<td>Siemens Ltd.</td>
<td>India</td>
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<td>11.</td>
<td>Spaceage Switchgears Limited</td>
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<td>12.</td>
<td>Tricolite Electrical Industries Pvt. Ltd.</td>
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<td>Venus Controls &amp; Switchgear (P) Ltd.</td>
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## Control & Relay Panel

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<td>1.</td>
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<td>2.</td>
<td>Asea Brown Boveri Ltd.</td>
<td>India</td>
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<td>C &amp; S Electric Ltd.</td>
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<td>5.</td>
<td>Larsen &amp; Toubro Ltd. (El. Products Divn)</td>
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## Protective Relays (other than BMR)

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<td>1.</td>
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<td>2.</td>
<td>Asea Brown Boveri Ltd.</td>
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<td>3.</td>
<td>Schneider – MICOM Model</td>
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<td>4.</td>
<td>SEL – Schweitzer Engineering Laboratories</td>
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<td>5.</td>
<td>Woodward</td>
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<td>6.</td>
<td>Siemens Ltd.- SIPROTEC Model</td>
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## Vacuum Circuit Breakers (VCB)

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<td>2.</td>
<td>Asea Brown Boveri Ltd.</td>
<td>India</td>
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<td>3.</td>
<td>BHEL (Electrical Machines Divn.)</td>
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<td>4.</td>
<td>Siemens Ltd.</td>
<td>India</td>
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<td><strong>Air Circuit Breakers (ACB)</strong></td>
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<tr>
<td>1. GE Power Controls India Pvt. Ltd.</td>
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<tr>
<td>2. Larsen &amp; Toubro Ltd. (El. Products Divn)</td>
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</tr>
<tr>
<td>3. Siemens Ltd.</td>
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<tr>
<td>4. ABB</td>
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<td>5. Schneider Electric</td>
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<th><strong>Moulded Case Circuit Breakers (MCCB)</strong></th>
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<td>1. Crompton Greaves Ltd.</td>
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<td>2. GE Power Controls India Pvt. Ltd.</td>
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<tr>
<td>3. Larsen &amp; Toubro Ltd. (El. Products Divn)</td>
<td>India</td>
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<td>4. Siemens Ltd.</td>
<td>India</td>
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<td>5. ABB</td>
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<tr>
<td>6. Schneider Electric</td>
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<table>
<thead>
<tr>
<th><strong>Miniature Circuit Breakers (MCB) / RCBO</strong></th>
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<tr>
<td>1. Indo Asian Fusegear Ltd</td>
<td>India</td>
</tr>
<tr>
<td>2. Legrand India Ltd</td>
<td>India</td>
</tr>
<tr>
<td>3. S &amp; S Power Switchgear Ltd</td>
<td>India</td>
</tr>
<tr>
<td>4. Standard Electricals Limited</td>
<td>India</td>
</tr>
<tr>
<td>5. Siemens Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>6. ABB</td>
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<td>7. Schneider Electric</td>
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<table>
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<th><strong>ELCB</strong></th>
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<tr>
<td>2. Havells India Ltd.</td>
<td>India</td>
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<tr>
<td>3. Indo Asian Fusegear Ltd</td>
<td>India</td>
</tr>
<tr>
<td>4. Legrand India Ltd</td>
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<td>5. S &amp; S Power Switchgear Ltd</td>
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<table>
<thead>
<tr>
<th><strong>Low Voltage Industrial Switches/Isolators</strong></th>
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<tr>
<td>1. Asea Brown Boveri Ltd.</td>
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<td>2. GE Power Controls India Pvt. Ltd.</td>
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<tr>
<td>3. Havells India Ltd.</td>
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<td>4. Kaycee Industries Ltd</td>
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</tr>
<tr>
<td>5. Larsen &amp; Toubro Ltd. (El. Products Divn)</td>
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<td>No.</td>
<td>Vendor Name</td>
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<tr>
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<tr>
<td>6.</td>
<td>Siemens Ltd.</td>
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<tr>
<td>7.</td>
<td>Schneider Electric</td>
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</tbody>
</table>

**Current Transformers (11 kV & 3.3 kV)**

<table>
<thead>
<tr>
<th>No.</th>
<th>Vendor Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Anant Powertech</td>
<td>India</td>
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<tr>
<td>2.</td>
<td>Asea Brown Boveri Ltd.</td>
<td>India</td>
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<tr>
<td>3.</td>
<td>Kalpa Electrical Private Limited</td>
<td>India</td>
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<tr>
<td>4.</td>
<td>Mehru Electricals (Formerly Automatic Electric Limited)</td>
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<td>Perfect Sales Corporation</td>
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<td>6.</td>
<td>Silkans</td>
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<td>Kappa</td>
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<tr>
<td>8.</td>
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**Potential Transformer (11 kV & 3.3 kV)**

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<th>No.</th>
<th>Vendor Name</th>
<th>Country</th>
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<tr>
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**Current Transformers (415V)**

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<td>Indcoil Transformers Pvt. Ltd.</td>
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<td>Kappa Electricals</td>
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**Potential Transformers (415V)**

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<td>Kappa Electricals</td>
<td>India</td>
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<td>5.</td>
<td>Larsen &amp; Toubro Ltd.(El. Products Divn)</td>
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<tr>
<td>6.</td>
<td>Mehru Electricals (Formerly Automatic Electric Limited)</td>
<td>India</td>
</tr>
<tr>
<td>No.</td>
<td>Company Name</td>
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<tr>
<td>1</td>
<td>Alstom Limited (Areva T &amp; D)</td>
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</tr>
<tr>
<td>2</td>
<td>IMP Power Ltd.</td>
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</tr>
<tr>
<td>3</td>
<td>M.B. Control &amp; Systems Pvt. Ltd.</td>
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</tr>
<tr>
<td>4</td>
<td>Meco Instruments</td>
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</tr>
<tr>
<td>5</td>
<td>Mehru Electricals (Formerly Automatic Electric Limited)</td>
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<tr>
<td>6</td>
<td>Rishabh Instruments Pvt. Ltd.</td>
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</tr>
<tr>
<td>7</td>
<td>Seahorse Industries Ltd.</td>
<td>India</td>
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</tbody>
</table>

**Meters**

- **Bus Ducts (11 kV & 3.3 kV)**
  2. Crompton Greaves Ltd.
  3. Intrelec
  4. Powergear Limited
  5. Spaceage Switchgears Limited
  6. Globe Electrical Industries (MV bus duct)

- **Bus Duct (415 V)**
  1. Anand Power Limited
  2. Associated Switchgears & Projects Ltd.
  3. Avone System & Controls
  5. C & S Electric Ltd.
  6. Controls & Schematics Pvt Ltd.
  7. Cosmic Power Systems Pvt. Ltd.
  8. DB Power Electronics Pvt. Ltd.
  9. Globe Electrical Industries
  10. Hindustan Control & Eqpt Pvt. Ltd
  11. Intrelec
  12. Lotus Powergear Pvt Ltd
  14. Powergear Limited
  15. Reunion Electrical Manufacturers (P) Ltd
  16. Shivalic Power Control (P) Ltd.
  17. Spaceage Switchgears Limited
  18. United Electric Co. (Delhi) Pvt. Ltd.
  19. Venus Controls & Switchgear (P) Ltd.

**Induction Motors – HV (11kV & 3.3 kV) (Safe/Hazardous Area)**

- BHEL (Electrical Machines Divn.)
<table>
<thead>
<tr>
<th></th>
<th>Company Name</th>
<th>Country</th>
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</thead>
<tbody>
<tr>
<td>2</td>
<td>Jeumont Industrie</td>
<td>France</td>
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<tr>
<td>3</td>
<td>Fuji Electric Systems Co. Ltd</td>
<td>Japan</td>
</tr>
<tr>
<td>4</td>
<td>Mitsubishi Corporation</td>
<td>Japan</td>
</tr>
<tr>
<td>5</td>
<td>Toshiba Corporation</td>
<td>Japan</td>
</tr>
<tr>
<td>6</td>
<td>Toshiba Mitsubishi Electric Industrial Systems Corporation (Excluding Flame-proof motors of frame size more than 900)</td>
<td>Japan</td>
</tr>
<tr>
<td>7</td>
<td>Peebles Electrical Machines</td>
<td>UK</td>
</tr>
<tr>
<td>8</td>
<td>Siemens</td>
<td>India / Germany</td>
</tr>
<tr>
<td></td>
<td>ABB</td>
<td>Finland/ Switzerland/India</td>
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**Induction Motors – LV (415 V) (Safe Area)**

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<tr>
<td>1</td>
<td>Asea Brown Boveri Ltd</td>
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</tr>
<tr>
<td>2</td>
<td>Bharat Bijlee Ltd</td>
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<tr>
<td>3</td>
<td>Crompton Greaves Ltd</td>
<td>India</td>
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<tr>
<td>4</td>
<td>Kirloskar Electric Company Ltd</td>
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</tr>
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<td>5</td>
<td>Siemens Ltd</td>
<td>India</td>
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<tr>
<td>6</td>
<td>Jeumont Industrie</td>
<td>France</td>
</tr>
<tr>
<td>7</td>
<td>Siemens AG, Germany</td>
<td>Germany</td>
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<tr>
<td>8</td>
<td>Fuji Electric Systems Co. Ltd</td>
<td>Japan</td>
</tr>
<tr>
<td>9</td>
<td>Mitsubishi Corporation</td>
<td>Japan</td>
</tr>
<tr>
<td>10</td>
<td>Toshiba Corporation</td>
<td>Japan</td>
</tr>
<tr>
<td>11</td>
<td>Asea Brown Boveri</td>
<td>Sweden</td>
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<tr>
<td>12</td>
<td>General Electric Co.</td>
<td>USA</td>
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**Induction Motors – LV (415 V) (Hazardous Area)**

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<td>2</td>
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<tr>
<td>3</td>
<td>Crompton Greaves Ltd</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>Kirloskar Electric Company Ltd</td>
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<td>5</td>
<td>Siemens Ltd</td>
<td>India</td>
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<td>6</td>
<td>Jeumont Industrie</td>
<td>France</td>
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<td>7</td>
<td>Siemens AG, Germany</td>
<td>Germany</td>
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<td>8</td>
<td>Fuji Electric Systems Co. Ltd</td>
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<td>9</td>
<td>Mitsubishi Corporation</td>
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<td>Toshiba Corporation</td>
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<td>Asea Brown Boveri</td>
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<tr>
<td>12</td>
<td>General Electric Co.</td>
<td>USA</td>
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**Industrial Type Sw. Socket & Plug**

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<td>1</td>
<td>Baliga Lighting Equipments Limited</td>
<td>India</td>
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<tr>
<td>2</td>
<td>Chloride Power Systems and Solutions Ltd. (formerly CALDYNE)</td>
<td>India</td>
</tr>
<tr>
<td>3</td>
<td>Crompton Greaves Ltd</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>Cyclo Electric Devices &amp; Services Co.</td>
<td>India</td>
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<tr>
<td>Vendor Name</td>
<td>Country</td>
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<tr>
<td>Ex-protecta</td>
<td>India</td>
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<tr>
<td>FCG Flameproof Control Gears Pvt. Ltd. (Formerly CEAG Flame)</td>
<td>India</td>
<td></td>
</tr>
<tr>
<td>FCG Power Industries Ltd</td>
<td>India</td>
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<tr>
<td>Flameproof Equipments Pvt. Ltd.</td>
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<tr>
<td>Legrand India Ltd</td>
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<tr>
<td>Legrand S.A.</td>
<td>France</td>
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<tr>
<td>BBC-Brown Boveri &amp; Cie AG</td>
<td>Germany</td>
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<tr>
<td>R Stahl Schaltgerate GmbH</td>
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<tr>
<td>Weidmuller Ltd.</td>
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<tr>
<td>CORTEM S.p.A.</td>
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**Street/Flood Lighting Fixtures**

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<tbody>
<tr>
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<tr>
<td>Crompton Greaves Ltd</td>
<td>India</td>
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<tr>
<td>Havells India Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>Philips India Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>Surya Roshni Ltd.</td>
<td>India</td>
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<tr>
<td>Wipro Lighting</td>
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**Hose Proof Industrial Lighting Fixtures**

<table>
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<td>Bajaj Electricals Limited</td>
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<td>Crompton Greaves Ltd</td>
<td>India</td>
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<tr>
<td>Philips India Ltd.</td>
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<tr>
<td>Surya Roshni Ltd.</td>
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<td>Wipro Lighting</td>
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**Air Obstruction Lights (Neon Type)**

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<td>Elecab Poysha</td>
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<tr>
<td>Wipro Lighting</td>
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**Lighting Poles**

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<td>Bharti Exports</td>
<td>India</td>
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<tr>
<td>Metalite Industries</td>
<td>India</td>
</tr>
<tr>
<td>Premier Power Products (Calcutta) Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>Sadhana Engineering Corporation</td>
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<tr>
<td>Surya Roshni Ltd.</td>
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**Explosion Proof Lighting Fixtures**

<table>
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<th>Country</th>
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<tr>
<td>Baliga Lighting Equipments Limited</td>
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<tr>
<td>Crompton Greaves Ltd</td>
<td>India</td>
</tr>
<tr>
<td>Ex-Protecta</td>
<td>India</td>
</tr>
<tr>
<td>FCG Flameproof Control Gears Pvt. Ltd. (Formerly CEAG Flame)</td>
<td>India</td>
</tr>
<tr>
<td>No.</td>
<td>Company Name</td>
</tr>
<tr>
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</tr>
<tr>
<td>5.</td>
<td>FCG Power Industries Ltd</td>
</tr>
<tr>
<td>6.</td>
<td>Flameproof Equipments Pvt. Ltd.</td>
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<td>7.</td>
<td>Flexpro Electricals Pvt. Ltd.</td>
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**Battery Charger**

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<th>No.</th>
<th>Company Name</th>
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<tbody>
<tr>
<td>1.</td>
<td>Amco Power Systems Limited</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>Chloride Power Systems and Solutions Ltd. (formerly CALDYNE)</td>
<td>India</td>
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<tr>
<td>3.</td>
<td>Chhabi Electricals Pvt. Ltd.</td>
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<tr>
<td>4.</td>
<td>HBL Nife Power Systems Ltd.</td>
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<tr>
<td>5.</td>
<td>Universal Industrial Products</td>
<td>India</td>
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**Battery (Ni-Cd)**

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<th>No.</th>
<th>Company Name</th>
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<tbody>
<tr>
<td>1.</td>
<td>AMCO Power Systems Ltd.</td>
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<tr>
<td>2.</td>
<td>HBL Nife Power Systems Ltd.</td>
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</tr>
<tr>
<td>3.</td>
<td>Fuji Electric Systems Co. Ltd.</td>
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<tr>
<td>4.</td>
<td>Hitachi Limited</td>
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**HT Power Cables**

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<thead>
<tr>
<th>No.</th>
<th>Company Name</th>
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<tbody>
<tr>
<td>1.</td>
<td>Cable Corpn. of India Limited</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>KEC International Ltd. (Formerly RPG Cables Limited)</td>
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</tr>
<tr>
<td>3.</td>
<td>KEI Industries Limited (Upto 33 kV)</td>
<td>India</td>
</tr>
<tr>
<td>4.</td>
<td>Ravin Cables Limited</td>
<td>India</td>
</tr>
<tr>
<td>5.</td>
<td>Torrent Cables Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>6.</td>
<td>Universal Cables Ltd.</td>
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<td>7.</td>
<td>Uniflex</td>
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<td>8.</td>
<td>Polycab</td>
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**LT Power Cables**

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<th>No.</th>
<th>Company Name</th>
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<tbody>
<tr>
<td>1.</td>
<td>Cable Corpn. of India Limited</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>Cords Cable Industries Ltd</td>
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</tr>
<tr>
<td>3.</td>
<td>Delton Cables Ltd</td>
<td>India</td>
</tr>
<tr>
<td>4.</td>
<td>Finolex Cables Ltd</td>
<td>India</td>
</tr>
<tr>
<td>5.</td>
<td>KEC International Ltd. (Formerly RPG Cables Limited)</td>
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</tr>
<tr>
<td>6.</td>
<td>KEI Industries Limited</td>
<td>India</td>
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<tr>
<td>7.</td>
<td>Plaza Cable Industries Limited</td>
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</tr>
<tr>
<td>8.</td>
<td>Ravin Cables Limited</td>
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<tr>
<td>9.</td>
<td>Torrent Cables Ltd</td>
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<tr>
<td>10.</td>
<td>Universal Cables Ltd.</td>
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<td>11.</td>
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**LT Control Cables (1.1 kV)**
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<td>1.</td>
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<tr>
<td>2.</td>
<td>Cords Cable Industries Ltd</td>
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<tr>
<td>3.</td>
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<tr>
<td>4.</td>
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<tr>
<td>5.</td>
<td>KEC International Ltd. (Formerly RPG Cables</td>
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<tr>
<td>6.</td>
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<td>7.</td>
<td>Plaza Cable Industries Limited</td>
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<td>8.</td>
<td>Radiant Cables Pvt. Limited</td>
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<td>11.</td>
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<td>Miracle cables</td>
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<td>13.</td>
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**Cables For Earthing**

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<th>Vendor Name</th>
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<tr>
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<td>2.</td>
<td>Delton Cables Ltd</td>
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<tr>
<td>3.</td>
<td>Finolex Cables Ltd</td>
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</tr>
<tr>
<td>4.</td>
<td>Gupta Electric &amp; Machinery Stores (GEMSCAB)</td>
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<tr>
<td>5.</td>
<td>J K Cables Limited</td>
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<td>6.</td>
<td>Netco Cable Industries (Pvt.) Ltd.</td>
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<td>7.</td>
<td>Prestige Cable Industries</td>
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<td>8.</td>
<td>Shyam Cables Industries</td>
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<td>9.</td>
<td>Special Cables Pvt. Ltd.</td>
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<td>10.</td>
<td>T C Communication Pvt Ltd.</td>
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<td>11.</td>
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**Cable Jointing Kits**

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<td>1.</td>
<td>Raychem RPG Ltd.</td>
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**Pre-Fabricated Al-Cable Trays**

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<th>Vendor Name</th>
<th>Country</th>
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<td>Globe Electrical Industries</td>
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<tr>
<td>2.</td>
<td>Hindustan Vidyut Products</td>
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<tr>
<td>3.</td>
<td>Indiana Engg Works Pvt Ltd</td>
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<td>4.</td>
<td>Indmark Formtech Pvt. Ltd.</td>
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<td>5.</td>
<td>Jamna Metal Company</td>
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<td>6.</td>
<td>Kanade Anand Udyog Pvt. Ltd.</td>
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<td>7.</td>
<td>Maheshwari Electrical Mfrs. (P) Ltd.</td>
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<td>8.</td>
<td>Metalite Industries</td>
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<tr>
<td>13</td>
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### Pre-Fabricated G.I. Cable Trays

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<td>3</td>
<td>Indmark Formtech Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>Jamna Metal Company</td>
<td>India</td>
</tr>
<tr>
<td>5</td>
<td>Kanade Anand Udyog Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>6</td>
<td>Maheshwari Electrical Mfrs. (P) Ltd.</td>
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</tr>
<tr>
<td>7</td>
<td>Metalite Industries</td>
<td>India</td>
</tr>
<tr>
<td>8</td>
<td>Parekh Engineering Company</td>
<td>India</td>
</tr>
<tr>
<td>9</td>
<td>Premier Power Products (Calcutta) Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>10</td>
<td>Rukmani Electricals &amp; Components Pvt Ltd</td>
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<tr>
<td>11</td>
<td>Sadhana Engineering Corporation</td>
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</tr>
<tr>
<td>12</td>
<td>Slotco Steel products Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>13</td>
<td>Sree Atreya Enterprises</td>
<td>India</td>
</tr>
<tr>
<td>14</td>
<td>Stealite Engg Co</td>
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### Hose Proof Local Control Station

<table>
<thead>
<tr>
<th>No.</th>
<th>Company Name</th>
<th>Country</th>
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<tbody>
<tr>
<td>1</td>
<td>Baliga Lighting Equipments Limited</td>
<td>India</td>
</tr>
<tr>
<td>2</td>
<td>Bhartia Industries Ltd. (Divn. Bch)</td>
<td>India</td>
</tr>
<tr>
<td>3</td>
<td>C &amp; S Electric Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>Ex-Protecta</td>
<td>India</td>
</tr>
<tr>
<td>5</td>
<td>FCG Flameproof Control Gears Pvt. Ltd. (Formerly CEAG Flame)</td>
<td>India</td>
</tr>
<tr>
<td>6</td>
<td>FCG Power Industries Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>7</td>
<td>Flameproof Equipments Pvt. Limited</td>
<td>India</td>
</tr>
<tr>
<td>8</td>
<td>Hotline Switchgear &amp; Controls</td>
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<tr>
<td>9</td>
<td>Power Engg Co</td>
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### Flameproof Items (Switch, Switch Socket, Plugs, Isolators, Junction Box, Local Control Station, Distribution Board)

<table>
<thead>
<tr>
<th>No.</th>
<th>Company Name</th>
<th>Country</th>
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<tbody>
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<td>4</td>
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<td>5</td>
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<td>6</td>
<td>Flexpro Electricals Pvt. Ltd.</td>
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<td>7</td>
<td>Legrand S.A.</td>
<td>France</td>
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<td>8</td>
<td>AEG Telefunken AG</td>
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<tr>
<td>9</td>
<td>BBC-Brown Boveri &amp; CIE AG</td>
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<td>10</td>
<td>R Stahl Schaltgerate GMBH</td>
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</table>
11. Siemens AG, Germany 
12. Weidmuller Ltd. Germany
13. Cortem S.p.A. Italy
14. Fuji Electric Systems Co. Ltd. Japan
15. Togami Electric Mfg. Company Japan
16. Toshiba Corporation Japan
17. Asea Brown Boveri Sweden
18. Crouse-Hinds (Europe) Ltd. U.K.
19. GEC Industrial Control Ltd. U.K.
20. M&C Switchgear U.K.

Hose proof Junction Boxes
1. Baliga Lighting Equipments Limited India
2. Bhartia Industries Ltd. (Divn. Bch) India
3. Ex-protecta India
4. FCG Flameproof Control Gears Pvt. Ltd. (Formerly CEAG Flame) India
5. Flameproof Equipments Pvt. Ltd. India
6. FCG Power Industries Ltd India

Limit Switches / Belt Monitoring Switches
1. A G System Controls India
2. AG Mechanical Enterprises (P) Ltd. India
3. Balaji Electricals India
4. Bhartia Industries Ltd. (Divn. Bch) India
5. Jayashree Electrodevices Pvt. Ltd. India
6. Protocontrol Instruments (I) Pvt. Ltd. India
7. R.K. Electrical Engg. Works India

Limit Switches (Flameproof Type)
1. Baliga Lighting Equipments Limited India
2. Ex-protecta India
3. FCG Flameproof Control Gears Pvt. Ltd. (Formerly CEAG Flame) India
4. Flameproof Equipments Pvt. Ltd. India
5. FCG Power Industries Ltd India
6. Protocontrol Instruments (I) Pvt. Ltd. India

Horn/Hooter/Klaxon
1. Baliga Lighting Equipments Limited India
2. Flameproof Equipments Pvt. Ltd. India
3. Worthmax Engineers India

Variable Speed Motor Package (HV Motors)
1. Asea Brown Boveri Ltd. Finland
2. BHEL (Electrical Machines Divn.) India
<table>
<thead>
<tr>
<th>Vendor Name</th>
<th>Country</th>
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<tbody>
<tr>
<td>3. Danfoss Industries Pvt. Ltd. (Upto 1400 KW)</td>
<td>India</td>
</tr>
<tr>
<td>4. Alsthom Atlantique</td>
<td>France</td>
</tr>
<tr>
<td>5. Siemens AG</td>
<td>Germany</td>
</tr>
<tr>
<td>6. Ansaldo Robicon</td>
<td>Italy</td>
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<tr>
<td>7. Fuji Electric Systems Co. Ltd.</td>
<td>Japan</td>
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<tr>
<td>8. Toshiba Mitsubishi Electric Industrial Systems Corporation</td>
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<td>9. GEC Industrial Control Ltd.</td>
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**Variable Speed Motor Package (LV Motors)**

<table>
<thead>
<tr>
<th>Vendor Name</th>
<th>Country</th>
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<tbody>
<tr>
<td>1. Amtech Electronics (India) Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>2. Asea Brown Boveri Ltd.</td>
<td>Finland</td>
</tr>
<tr>
<td>3. BHEL (Electrical Machines Divn.)</td>
<td>India</td>
</tr>
<tr>
<td>4. Crompton Greaves Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>5. Danfoss Industries Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>6. Larsen &amp; Toubro Ltd. (El. Products Divn)</td>
<td>India</td>
</tr>
<tr>
<td>7. Kirloskar Electric Company Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>8. Rockwell Automatic India Ltd.</td>
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</tr>
<tr>
<td>9. Siemens Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>10. Alsthom Atlantique</td>
<td>France</td>
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<tr>
<td>11. Siemens AG</td>
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<td>14. Toshiba Mitsubishi Electric Industrial Systems Corporation</td>
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<td>15. GEC Industrial Control Ltd.</td>
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**Capacitors**

<table>
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<th>Vendor Name</th>
<th>Country</th>
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<tbody>
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<td>1. BHEL (Electrical Machines Divn.)</td>
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<tr>
<td>2. Crompton Greaves Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>3. Kapsales Electricals Ltd.</td>
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<tr>
<td>4. Shreem Capacitors Pvt. Ltd.</td>
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</tr>
<tr>
<td>5. Universal Cables Ltd.</td>
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<tr>
<td>6. Asea Brown Boveri Ltd.</td>
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**Earthing & Lightning Protection Material – (Al) Wire/Strip**

<table>
<thead>
<tr>
<th>Vendor Name</th>
<th>Country</th>
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<tbody>
<tr>
<td>1. Anand Electric Trading Co.</td>
<td>India</td>
</tr>
<tr>
<td>2. C &amp; S Electric Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>3. Indmark Formtech Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>4. Jayant Metal Mfg. Co.</td>
<td>India</td>
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<tr>
<td>5. Premier Power Products (Calcutta) Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>6. Jamna Metal Company</td>
<td>India</td>
</tr>
<tr>
<td>7. Mahavir Industrial Corporation</td>
<td>India</td>
</tr>
<tr>
<td>8. Metropolitan Industries</td>
<td>India</td>
</tr>
<tr>
<td>9. Sai Galvanisers &amp; Fabricators Pvt Ltd</td>
<td>India</td>
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<tr>
<td><strong>Earthing &amp; Lightning Protection Material – (GI) Wire/Strip</strong></td>
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<tr>
<td>---------------------------------------------------------------</td>
<td></td>
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<tr>
<td><strong>1.</strong> Anand Electric Trading Co.</td>
<td>India</td>
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<tr>
<td><strong>2.</strong> Controls &amp; Switchgear Co. Ltd.</td>
<td>India</td>
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<td><strong>3.</strong> Jayant Metal Mfg. Co.</td>
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</tr>
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<td><strong>4.</strong> Indmark Formtech Pvt. Ltd.</td>
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<td><strong>9.</strong> Sai Galvanisers &amp; Fabricators Pvt Ltd</td>
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<tr>
<td><strong>10.</strong> Bharti Exports</td>
<td>India</td>
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<tr>
<td><strong>11.</strong> Metalite Industries</td>
<td>India</td>
</tr>
<tr>
<td><strong>12.</strong> Rukmani Electricals &amp; Components Pvt Ltd</td>
<td>India</td>
</tr>
<tr>
<td><strong>13.</strong> Sadhana Engineering Corporation</td>
<td>India</td>
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<tr>
<td><strong>14.</strong> Stealite Engg Co</td>
<td>India</td>
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<table>
<thead>
<tr>
<th><strong>GI Pipes &amp; Conduits</strong></th>
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<tbody>
<tr>
<td><strong>1.</strong> Bharti Exports</td>
</tr>
<tr>
<td><strong>2.</strong> Indian Tube Co. (Tata Div. of Tubes &amp; Pipes)</td>
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<tr>
<td><strong>3.</strong> Jindal Pipes Ltd.</td>
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<tr>
<td><strong>4.</strong> Meghiyot Enterprises</td>
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<td><strong>5.</strong> Rukmani Electricals &amp; Components Pvt Ltd</td>
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<tr>
<td><strong>6.</strong> Steelcraft</td>
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<table>
<thead>
<tr>
<th><strong>Industrial Cable Gland</strong></th>
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<tbody>
<tr>
<td><strong>1.</strong> Baliga Lighting Equipments Limited</td>
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<tr>
<td><strong>2.</strong> Comet Brass Products</td>
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<tr>
<td><strong>3.</strong> Comet Industries</td>
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<tr>
<td><strong>4.</strong> Dowell's Electricals</td>
</tr>
<tr>
<td><strong>5.</strong> Electromac Industries</td>
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<td><strong>6.</strong> FCG Flameproof Control Gears Pvt. Ltd. (Formerly CEAG Flame)</td>
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<tr>
<td><strong>7.</strong> Gland-Mech. Industries</td>
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<td><strong>8.</strong> Industrial products Equipment</td>
</tr>
<tr>
<td><strong>9.</strong> Power Engg Co</td>
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<tr>
<td><strong>10.</strong> Quality &amp; Precision Indl. Equipment</td>
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<td><strong>11.</strong> S J Metal Industries (Jainson)</td>
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<table>
<thead>
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<th><strong>Cable Lugs</strong></th>
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<td><strong>1.</strong> Dowell's Electricals</td>
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<td><strong>2.</strong> Forward Engg Industries</td>
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<td><strong>3.</strong> KSE Electrical Pvt. Ltd.</td>
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<td><strong>4.</strong> MG Electrica</td>
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<td><strong>5.</strong> Power Engg Co</td>
</tr>
<tr>
<td><strong>6.</strong> S J Metal Industries (Jainson)</td>
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<tr>
<td><strong>7.</strong> Usha Martin Industries Ltd. (Ismal Divn)</td>
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</table>
### Flameproof Cable Gland
1. Baliga Lighting Equipments Limited
2. Comet Brass Products
3. Comet Industries
4. Dowell's Electricals
5. Electromac Industries
6. Ex-Protecta
7. FCG Flameproof Control Gears Pvt. Ltd. (Formerly CEAG Flame)
8. FCG Power Industries Ltd
10. Flexpro Electricals Pvt. Ltd.
11. Industrial Products Equipment
13. Power Engg Co
14. Prompt Engineering Works
15. Sudhir Switchgears Pvt. Ltd.

### Explosion Proof Exhaust Fan
1. Alstom Limited (Areva T & D)
2. Crompton Greaves Ltd
3. FCG Flameproof Control Gears Pvt. Ltd. (Formerly CEAG Flame)
4. Flameproof Equipments Pvt. Ltd.

### LIFT
1. Otis Elevator Co (I) Ltd
2. Daiichi Jitsugyo Co., Ltd.
3. Fuji Electric Systems Co. Ltd.
4. Nippon Elevator Ind.Co. Limited
5. Schindler Ag

### Cathodic Protection
1. M/s Raychem RPG Ltd
2. M/s Consultech
3. M/s Afcons Corrosion protection Pvt Ltd (Formerly SSS Electricals (I) Pvt Ltd.)
4. M/s Corrosion Control Services (Bombay) Pvt Ltd
5. M/s Corrtech, Ahmedabad
6. M/s CTS Private Limited
7. M/s Corrtech International Pvt Ltd
8. SARK EPC Projects pvt. Ltd.

### Diesel Generator Set
1. Caterpillar
2. Cummins India Limited
3. Garden Reach Shipbuilders & Engineers Ltd.
4. Wartsila India Ltd.
<table>
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<tr>
<th>Fuse</th>
<th>India</th>
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<tbody>
<tr>
<td>1.</td>
<td>Larsen &amp; Toubro Ltd. (El. Products Divn.)</td>
</tr>
<tr>
<td>2.</td>
<td>Siemens Ltd.</td>
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<tr>
<td>3.</td>
<td>Alstom Power</td>
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<td>4.</td>
<td>Havells India Ltd.</td>
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<table>
<thead>
<tr>
<th>Contactor / Relay /</th>
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<tbody>
<tr>
<td>1.</td>
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<thead>
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<td>Bhartia Cutler Hammer</td>
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<td>4.</td>
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<td>5.</td>
<td>Tulsi</td>
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<td>2.</td>
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<td>3.</td>
<td>Larsen &amp; Toubro Ltd. (El. Products Divn.)</td>
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<td>4.</td>
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<td>Elmex</td>
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<td>4.</td>
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<td><strong>FRP Cable Trays</strong></td>
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<td>1. Enercon</td>
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<td>2. Ercon Composites (Upto 600 Mm Wide)</td>
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<td>3. Kemrock</td>
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<td>4. Satyam Industries</td>
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<td>5. Sintex Industries Ltd.</td>
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<td>6. Sumip Composites Pvt Ltd.</td>
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<td>1. Bajaj Electricals Limited</td>
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<td>2. Philips India Ltd.</td>
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<thead>
<tr>
<th><strong>Programmable Logic Controller</strong></th>
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<td>1. Rockwell Automation India Pvt. Ltd.</td>
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<tr>
<td>2. Siemens Ltd.</td>
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<td>3. Asea Brown Boveri Ltd</td>
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<td>1. Finolex</td>
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<td>2. DLink</td>
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<td>1. Crompton</td>
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</tr>
<tr>
<td>2. Elster (ABB)</td>
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<td>1. Advance Electronic Systems</td>
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</tr>
<tr>
<td>2. Raychem</td>
<td>India</td>
</tr>
<tr>
<td>3. Canara Electricals</td>
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<tr>
<td>4. Corrpro Systems</td>
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<tr>
<td>5. Kristons Systems</td>
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<table>
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<tr>
<th><strong>Test Stations/ Anode Junction Box/ Cathode Junction Box / Surge Arrestor Junction Box/ Reference Electrode Junction Box (REJB) / Earthing Junction Box (EJB)</strong></th>
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<tbody>
<tr>
<td>1. Corrpro Systems</td>
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<tr>
<td>2. Advance Electronic Systems</td>
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<tr>
<td>3. Baliga Lighting Equipments Ltd.</td>
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<tr>
<td>4. FCG Flameproof Control Gears Pvt. Ltd.(Formerly CEAG Flame)</td>
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<tr>
<td>5. Flameproof Equipments Pvt. Ltd.</td>
<td>India</td>
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<td>6. Flexpro Electricals Pvt. Ltd.</td>
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<tr>
<th><strong>Permanent Reference Electrode</strong></th>
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<tr>
<td>1. Advance Electronic Systems</td>
<td>India</td>
</tr>
<tr>
<td>2. Borin, USA</td>
<td>USA</td>
</tr>
<tr>
<td>3. M C Miller, USA</td>
<td>USA</td>
</tr>
<tr>
<td>4. Cer Anode, USA</td>
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<tr>
<td>5. Harco, USA</td>
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<tr>
<td>Surge Diverter for MIJS</td>
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<td>-----------------------------------------------------------</td>
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<tr>
<td>1. Advance Electronic Systems</td>
<td>USA</td>
</tr>
<tr>
<td>2. DEHN</td>
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</tr>
<tr>
<td>3. Hockway</td>
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<td>4. OBO Betterman</td>
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<tr>
<th>Monolithic Isolating Joints</th>
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<td>1. Advance Electronic Systems</td>
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<td>2. Alfa Engineering</td>
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<tr>
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<td>4. Zunt Italy</td>
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<td>5. RMA Italy</td>
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<td>6. Advance Products,</td>
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<tr>
<th>Calcined Petroleum Coke Breeze</th>
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<tr>
<td>1. Goa Carbon</td>
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<td>2. India Carbon (Calcutta)</td>
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<tr>
<td>3. Petro Carbon &amp; Chem. Company</td>
<td>India</td>
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<td>4. LORESCO SC-2</td>
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<tr>
<th>Zinc Grounding Electrode/ Cell/ Zinc Ribbon Anode</th>
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<td>Magnesium Anodes (For TCP)</td>
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<tr>
<td>1. Sargam Metals Chennai</td>
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<tr>
<td>2. Advance Electronic Systems</td>
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<tr>
<td>3. Corrpro Systems</td>
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<td>4. Scientific Metals Karaikudi</td>
<td>India</td>
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<td>5. Corrtech Metals</td>
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<tr>
<th>Mixed Metal Oxide Wire Anode</th>
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<tr>
<td>1. Mactor</td>
<td>USA</td>
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<tr>
<td>2. Covalence</td>
<td>USA</td>
</tr>
<tr>
<td>3. Tyco Adhesive</td>
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<tr>
<td>4. Berry Plastic</td>
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<th>Mixed Metal Oxide Tubular Anode</th>
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<tbody>
<tr>
<td>1. Titanor Components Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>2. Oranzio De Nora,</td>
<td>Italy</td>
</tr>
<tr>
<td>3. Magnetochemie</td>
<td>Holland</td>
</tr>
<tr>
<td>4. Actel Ltd.</td>
<td>U.K.</td>
</tr>
<tr>
<td>5. Eltech Systems Corporation</td>
<td>USA</td>
</tr>
<tr>
<td>6. Ceraanode</td>
<td>USA</td>
</tr>
<tr>
<td>7. Mactor</td>
<td>USA</td>
</tr>
<tr>
<td>8. De Nora India Ltd</td>
<td>USA</td>
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</table>

<table>
<thead>
<tr>
<th>Permanent reference Electrodes</th>
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<tbody>
<tr>
<td>1. Borin</td>
<td>USA</td>
</tr>
<tr>
<td>2. Mc-Miller</td>
<td>USA</td>
</tr>
</tbody>
</table>
3. Harco USA
4. 

**DC clip-on meter**
1. HCK Germany
2. Kyoritsu Elect Japan

**Reference Electrode (Zinc) / Zinc Reference Cell**
1. Scientific Metal Engineers India
2. Karaikudi India
3. Sargam Metal Chennai India

**Solid-State type Polarization cells**
1. Dairy Land, USA
2. Rustrol USA
3. Advanced Electronics Systems India
4. Kirk USA
5. Corrpro USA

**Insulating Flange Gasket Kit Joints**
1. ALFA Italy
2. ZUNT Italy
3. IGP India

**Monitoring Junction Box (MJB)**
**Remote Monitoring Unit**
1. Raychem India
2. Advanced Electronics Systems India

**Heat Shrink Cap Anode Cable Joint:**
1. Raychem USA
2. MATCOR USA

### 5.0 CIVIL:

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>ITEM</th>
<th>NAME</th>
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<tbody>
<tr>
<td>1.0</td>
<td>FLOOR FINISHING</td>
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</table>
| 1.1     | CEMENT TILES (FLOOR/WALL) | a) EUROCON  
|         |         | b) ALTRA TILE PVT. LTD.  
|         |         | c) DAZZLE  |
| 1.2     | TERRAZZO TILES | a) NITCO  
|         |         | b) HINDUSTAN TILES |
| 1.3 | CERAMIC TILES | a. SOMANY CERAMICS  
b. H&R JOHNSON CERAMICS  
c. KAJARIA CERAMICS  
d. ORIENT CERAMICS |
| 1.4 | HEAVY DUTY FLOOR TILES | a) BHARAT TILES  
b) RESTILE CERAMICS  
c) PELICAN CERAMIC INDUS.  
d) PAVIT  
e) SONA TILES |
| 1.5 | INDUSTRIAL FLOOR HARDENER ADMIXTURE | a) PIDILITE INDUSTRIES  
b) SIKA  
c) CICO. |
| 1.6 | PVC ROLLS | a) PREMIER VINYL  
b) ARMSRONG INARCO  
c) RMG POLYVINYL |
| 1.7 | PVC TILES | a) ARMSTRONG |
| 1.8 | PVC TILES/ROLL ANTISTATIC | a) PREMIER VINYL  
b) RMG POLYVINYL  
c) ARMSTRONG |
| 1.9 | ACID RESISTANT TILES(BATTERY ROOM) | a) H&R JOHNSON OR APVD. EQUIV. |
| 1.10 | MOSSAIC TILE | a) ITALIS  
b) SPECIFIC GLASS MUSSAIC INDIA LTD. |
| 2.0 | WOODWORK |
| 2.1 | FLUSH DOOR | a) GREEN  
b) CENTURY DOORS  
c) KITPLY PRODUCTS |
| 2.2 | PLY WOOD/BLOCK BOARD | a) CENTURY  
b) KITPLY PRODUCTS  
c) GREEN PLY |
| 2.3 | PARTICLE BOARD (EXTRA GRADE) | a) BHUTAN BOARD  
b) NOVAPAN INDIA LTD. |
| 2.4 | MDF BOARD/MD PARTICLE BOARD (EXTRA GRADE) | a) NUCHEM LTD.  
b) MANGALAM TIMBER PRODUCTS LTD. |
| 2.5 | DECORATIVE LAMINATES | a) CENTURY  
|     |                     | b) GREENPLY INDUS. LTD.  
|     |                     | c) MERINO  
|     |                     | d) ARCHID  
| 2.6 | MARINE PLYWOOD | a) CENTURY  
|     |                     | b) GREENPLY INDUS. LTD.  
|     |                     | c) MERINO  
|     |                     | d) ARCHID  
| 2.7.0 | DOORS & WINDOWS FITTINGS |  
| 2.7.1 | MORTICE LOCKS WITH HANDLES | a) GODREJ & BOYCE  
|       |                     | b) EVERITE AGENCIES (P) LTD.  
|       |                     | c) DOORSET  
| 2.7.2 | CYLINDRICAL PIN TUMBLER LOCK WITH KNOBS | a) GODREJ & BOYCE  
|       |                     | b) EVERITE AGENCIES (P) LTD.  
|       |                     | c) DOORSET  
| 2.7.3 | HYDRAULIC DOOR CLOSER (OVER HEAD/ FLOOR) | a) OZONE  
|       |                     | b) EVERRITE AGENCIES (P) LTD.  
|       |                     | c) HARDWYN  
| 2.7.4 | MISCELLANEOUS DOOR FITTINGS HINGE, TOWER BOLTS, LATCHES, SOPPER, STAYS, ALDROPS ETC. | a) EVERITE AGENCIES (P) LTD.  
|       |                     | b) EBCO DINSUTRIES  
|       |                     | c) OZONE  
|       |                     | d) HARDWYN  
| 2.7.5 | THREE WAY BOLTING LOCKING DEVICE HANDLE | a) SRIMA SALES & SERVICES  
|       |                     | b) DHIMAN INDUSTRIES  
| 2.7.6 | PANELED BAR LATCH (FOR EMERGENCY DOOR) | a) SRIMA SALES & SERVICES  
| 2.7.7 | UPVC WINDOWS | a) FENESTA  
|       |                     | b) ENCRAFT  
|       |                     | c) WINDOW MAGIC  
| 2.7.8 | FASTENERS | a) HILTI INDIA PVT. LTD.  
|       |                     | b) FISCHER  
| 3.0 | STEEL / ALUMINIUM DOORS, WINDOWS & VENTILATOR |  
| 3.1 | PRESSED STEEL DOORS WINDOWS & SECTION DOORS WINDOWS/ROLLING SHUTTER | a) RAYMUS ENGINEERS  
|       |                     | b) DHIMAN STEEL  
|       |                     | c) RDG ENGINEERING  
|       |                     | d) SUPER STEEL WINDOW CO.  
|       |                     | e) SKS STEEL INDUS.  
| 3.2 | ALUMINIUM / DOORS/ WINDOWS SECTIONS | a) JINDAL ALUMINIUM LTD.  
|       |                     | b) HINDALCO INDUSTRIES  
|       |                     | c) INDAI  
| 3.3 | FIRE-PROOF DOORS(APPROVED) | a) NAVAIR INTERNATIONAL  
|       |                     | b) RDG ENGINEERING  
| 3.4 | PVC DOORS / WINDOWS | a) SINTEX Or APPVD EQUIV.  
| 3.5 | PVC WATER TANKS | a) SINTEX Or APPVD EQUIV.  
| 4.0 | PLASTERING |  
| 4.1 | WATERPROOFING/ COMPOUND IN CEMENT PLASTER | a) STRUCTURAL WATER PROOFING CO. (P) LTD.  

FORM NO: 02-0000-0021 F3 REV5 All rights reserved
### 5.0 ROOF TREATMENT (WATER PROOFING)

<table>
<thead>
<tr>
<th>Item</th>
<th>Vendors</th>
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</table>
| 5.0  | b) PIDILITE INDUSTRIES  
      | c) SIKA |
| 5.1  | BRICK BAT COBA  
      | a) INDIA WATER PROOFING CO.  
      | b) OVERSEAS WATERPROOFING CORPN. |
| 5.2  | CRYLIC BASED CEMENTIOUS PRIMER COATING FOR ROOF WATERPROOFING  
      | a) STRUCTURAL WATER PROOFING CO. (P) LTD.  
      | b) SIKA QUALCRETE LTD.  
      | c) PIDILITE INDUSTRIES |
| 5.3  | APP MODIFIED POLYMERIC WASTER PROOFING MEMBRANE  
      | a) PIDILITE INDUSTRIES LTD.  
      | b) SIKA |

### 6.0 PAINTING WORKS

<table>
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<th>Item</th>
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| 6.0  | b) PIDILITE INDUSTRIES  
      | c) SIKA |
| 6.1  | PLASTIC EMULSION (INTERIOR/EXTERIOR)  
      | a) ICI INDIA LTD.  
      | b) BERGER PAINTS LTD.  
      | c) ASIAN PAINTS LTD.  
      | d) SHALIMAR PAINTS  
      | e) KANSAI NEROLAC PAINTS LTD. |
| 6.2  | DRY OILBOUND DISTEMBER  
      | a) ASIAN PAINTS LTD.  
      | b) KANSAI NEROLAC PAINTS LTD. |
| 6.3  | INDUSTRIAL / EXPOXY/ SYNTHETIC ENAMEL PAINTS  
      | a) ICI/AKZO NOBEL INDIA  
      | b) BERGER PAINTS LTD.  
      | c) ASIAN PAINTS LTD.  
      | d) SHALIMAR PAINTS  
      | e) INTERNATIONAL MARINE COATINGS PVT. LTD.  
      | f) KANSAI NEROLAC PAINTS LTD.  
      | g) BOMBAY PAINT |
| 6.4  | WATERPROOFING CEMENT PAINT  
      | a) KILLICK NIXON LTD.  
      | b) RAJDOOT PAINTS |
| 6.5  | WOOD MELAMINE POLISH  
      | a) ASIAN PAINTS  
      | b) SHALIMAR PAINTS  
      | c) WEMBLY PAINTS |
| 6.6  | WATERPROOFING TRANSPARENT EXTERIOR WALL COATING (OVER PAINTED SURFACE)  
      | a) PIDILITE INDUSTRIES  
      | b) SIKA |
| 6.7  | FIRE PROOF COATING  
      | a) NAVAIR INTERNATIONAL OR APPVFD. EQUIV. |

### 7.0 ROOFING SHEETS & ACCESSORIES

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<tr>
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<th>Vendors</th>
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</table>
| 7.0  | b) PIDILITE INDUSTRIES  
      | c) SIKA |
| 7.1  | ASBESTOS SHEETS  
      | a) ETERNIT EVEREST LTD.  
      | b) CHARMINAR INDUSTRIES  
      | c) VISAKA |
| 7.2 | C.G.I. SHEETS                              | a) ISPAT INDUSTRIES LTD.   
    |                                             | b) STEEL AUTHORITY OF INDIA 
    |                                             | c) TATA STEEL               
    |                                             | d) JINDAL                   |
| 7.3 | PRECOATED G.I. PROFILE SHEETS FOR ROOFING & WALL CLADDING | a) ISPAT INDUSTRIES LTD.   
    |                                             | b) LLOYD INSULATION (I) LTD. 
    |                                             | c) STEEL AUTHORITY OF INDIA 
    |                                             | d) TATA STEEL               
    |                                             | e) JINDAL                   |
| 7.4 | ALUMINIUM SHEET (PLAIN/PROFILE)            | a) INDIAN ALUMINIUM CO. LTD. Or 
    |                                             | APPROVED EQUIVALENT         |
| 7.5 | FIBRE GLASS SHEETS & PANELS (MACHINE MOULDED) | a) SIMBA FRP (P) LTD.      
    |                                             | b) GE INDIA                 
    |                                             | c) Duroplast                |
| 7.6 | PROOFING J/L HOOKS, BOLTS & OTHER ACCESSORIES (POLYMER COATED) | a) KATALIST CONSULTANT (P) LTD. 
    |                                             | b) ADVANCED MACHINE         |
| 8.0 | SANITARY PLUMBING FITTINGS & FIXTURES      | a) HINDUSTAN SANITARY WARE & INDUS. LTD.  
    | 8.1 | SANITARY FITTINGS (W.C. WASH BASIN, URINAL ETC.) | b) PARRYWARE SANITARY WARE  
    |                                             | c) MADHUSUDAN CERAMICS       
    |                                             | d) NYCER CERAMICS            |
| 8.2 | PLUMBING FITTINGS & FIXTURES               | a) JAGUAR                   
    |                                             | b) CERA                     
    |                                             | c) HINDWARE                 |
| 8.3 | GLASS/MIRROR (SHEET/ FLOAT/ TOUGHENED/ LAMINATION) | a) GUJARAT GUARDIAN LTD.    
    |                                             | b) SAINT GOBAIN              
    |                                             | c) ASAHI FLOAT               |
| 8.4 | GI PIPES                                   | a) JINDAL                   
    |                                             | b) SURYA                    
    |                                             | c) PRAKASH                  
    |                                             | d) SWASTIK                  |
| 9.0 | FALSE CEILING, FALSE FLOORING & UNDERDECK INSULATION | a) INTERARCH BUILDING PRODUCTS(P) LTD. 
    | 9.1 | FLASE CEILING / WALL CLADDING (ALUMINIUM STRIP/ TRAY TYPE) | b) HUNTER DOUGLAS        
    |                                             | c) MASCOT OVERSEAS          |
| 9.2 | FALSE FLOORING                             | a) MULTI INTERIORS PVT. LTD. 
    |                                             | b) BESTLOCK SYSTEM & CONCEPTS  
    |                                             | c) LLOYD INDUSULATION (I) LTD. 
    |                                             | d) UNITED INSULATION        
<pre><code>|                                             | e) A.R. &amp; BROTHERS           |
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<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
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</table>
| 9.3     | UNDERDECK/WALL HEAT INSULATION                   | a) BAKELITE HYlam LTD.  
b) U.P. TWIGA F.G. LTD.  
c) LLOYD INDULATION (I) LTD.  
d) SUPEREME |
| 9.4     | OVERDECK HEAT INSULATION                         | a) LLOYD INSULATION (I) LTD.  
b) BEST PLASTRONICS LTD. |
| 9.5     | GYPSUM BOARD TILES (FIBRE GLASS REINFORCED)      | a) SAINT GOBAIN                                                             |
| 10.0    | SPECIALITY PRODUCTS (CEMENT ADDITIVES/            | a) PIDILITE INDUSTRIES  
b) SIKA                                                                 |
|         | ADMIXTURES/CORROSION INHIBITORS/SURFACE          |                                                                             |
|         | TREATMENT/GROUT & ANCHORS/SEALING/COASTING       |                                                                             |
| 10.1    | EPOXY FLOOR COATING (BATTERY ROOM)               | a) SIKA  
b) FAIRMATE                                                  |
| 11.0    | MISCALLANEOUS ITEMS                              |                                                                             |
| 11.1    | WOOD PRESERVATIVE                                | a) ASCU HICKSON LTD.                                                        |
| 11.2    | WALL SURFACE TEXTURED COATING                    | a) JOTUN  
b) SPECTRUM PAINTS  
c) BAKELITE HYlam  
d) OIKOS |
| 11.3    | PVC PLUMBING FITTINGS                            | a) SUPREME  
b) POLYPAC  
c) ASTROL                                                      |
| 11.4    | REINFORCED FIBRE GLASS WATERPROOFING FELT        | a) SIKA  
b) U.P. TWIGA F.G. LTD. |
| 11.5    | ANTI TERMITE TREATMENT                            | a) PCI Or APPRVD EQUIV.                                                     |
| 11.6    | MATERIAL TEST HOUSE                              | a) IIT MADRAS  
b) GOVT APPROVED AGENCY                                  |
| 12.0    | CEMENT                                           | a) ACC  
b) J K CEMENT  
c) BINANI CEMENT  
d) JP CEMENT  
e) GUJARAT AMBUJA  
f) ALTRA TECH CEMENT |
| 12.1 | SULPHUR RESISTANT CEMENT | g) BIRLA CORPN. LTD.  
|      |                        | h) GRASIM  
|      |                        | i) SHREE  
| 13.0 | RCC DESIGN MIX         | a) SAURASHTRA CEMENT LTD.  
|      |                        | b) SHREE DIGVIJAY CEMENT  
| 14.0 | WRAPPING COATING (I/C TAPE & PRIMER) IWL OR APPROVED EQUIPMENT | a) IWL OR APPROVED EQUIVALENT  
| 15.0 | FIRE PROOFING MATERIAL | a) CAFCO  
|      |                        | b) CARBOLINE  
| 16.0 | STRUCTURAL STEEL / CS PLATE | HEAVY SECTIONS MORE THAN 150 mm  
|      |                        | a) SAIL  
|      |                        | b) TATA STEEL  
|      |                        | c) RINL  
|      |                        | LIGHT SECTIONS less Than 150 mm  
|      |                        | d) ESSAR  
|      |                        | e) ISPAT INDUSTRIES  
|      |                        | f) JINDAL STEEL & POWER LTD  
| 16.1 | MS PIPES (HAND RAIL APPLICATION) | a) SURYA  
|      |                        | b) PRAKASH  
|      |                        | c) JINDAL  
| 17.0 | TIMT BAR / REBAR       | a) SAIL  
|      |                        | b) TATA STEEL  
|      |                        | c) RINL  
|      |                        | d) SHYAM STEEL INDUSTRIES LIMITED  
| 18.0 | GRATINGS/HANDRAILS     | a) INDIANA GRATINGS  
|      |                        | b) WESTCOAST ENGINEERING  
|      |                        | c) GREATWELD GRATING  
|      |                        | d) KANADE ANAND UDYOG  
| 19.0 | WELDING ELECTRODE      | a) ADOR  
|      |                        | b) ESAB  
|      |                        | c) D & H  
|      |                        | d) HANOVAR  

**GENERAL NOTES FOR CIVIL:**

1. Only ‘First’ Quality materials shall be used
2. OWNER / CONSULTANT reserve the right to choose any of the approved make / vendor as per this list.
3. Specifications of manufacturer’s items shall be checked against tender item / specifications before selecting any product or brand name. In case of any discrepancy, tender item / specifications shall prevail, and any such brand of item shall not be used which is not conforming to tender specifications even if it is listed in this vendor list.

4. In case of non-availability of any material among approved vendors / makes in a particular site / region, alternate vendor / make conforming to IS / BS etc. Shall be used subject to approval by OWNER / CONSULTANT.

6.0 MATERIAL HANDLING:

**COAL AND ASH HANDLING SYSTEM:**

<table>
<thead>
<tr>
<th>SL.No.</th>
<th>Vendor’s Name</th>
<th>Country</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Ash Handling System</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Desein (INDURE) Private Limited</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>Macawber Beekay Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>United Conveyor Corporation</td>
<td>India</td>
</tr>
</tbody>
</table>

|        | Pneumatic Handling System          |         |
| 1.     | Acme Air Pvt. Ltd.                 | India   |
| 2.     | Macawber Beekay Pvt. Ltd.          | India   |
| 3.     | Coperion Idea Pvt. Ltd.            | India   |

|        | Bucket Elevator                    |         |
| 1.     | Bengal tools limited               | India   |
| 2.     | Indiana conveyors pvt. ltd         | India   |
| 3.     | Elecon Engg. Co. ltd               | India   |
| 4.     | TRF limited                        | India   |
| 5.     | Cobit Engineering Pvt Ltd          | India   |

|        | Conveyor system / feeder including Transfer Chutes, Bunkers /Hoppers | |
| 1.     | Bengal tool limited              | India |
| 2.     | Elecon Engg. Co. ltd             | India |
| 3.     | Macnally Bharat Engg. Co. Ltd    | India |
| 4.     | TRF limited                      | India |
| 5.     | Indiana conveyors pvt. ltd       | India |
| 6.     | Cobit Engineering Pvt Ltd        | India |

|        | Conveyor Belting                   |         |
| 1.     | Phoenix conveyor belt limited      | India   |
| 2.     | MRF Ltd.                          | India   |
| 3.     | Oriental Rubber Industries Ltd.    | India   |
| 4.     | Universal Conveyor belting ltd.   | India   |
| 5.     | Anil Rubber Mills Pvt. Ltd.       | India   |

<p>|        | Belt Conveyor Components (Idlers &amp; Pulleys) |         |
| 1.     | Elecon Engg. Co. Ltd.                 | India   |
| 2.     | TRF Ltd.                             | India   |
| 3.     | Indiana conveyors system             | India   |
| 4.     | Mcnally Bharat co. ltd              | India   |
| 5.     | Fenner (India) Ltd.                  | India   |</p>
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<tr>
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<th>Country</th>
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<tr>
<td>6. Masyc Projects Pvt. Ltd</td>
<td>India</td>
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<tr>
<td>7. Cobit Engg Pvt. Ltd.</td>
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</tr>
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<td>8. Bengal tool limited</td>
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**Crusher & Vibrating screen**

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<tr>
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<tr>
<td>3. TRF limited</td>
<td>India</td>
</tr>
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<td>4. Mcnally Bharat Engg. Co. Ltd</td>
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<td>5. International Combustion</td>
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**Gear Reducer & Gear Boxes**

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<td>2. New Allenbury Works.</td>
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<td>3. FMG</td>
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<td>4. Elecon Engineering co. Ltd.</td>
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**Bearings**

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<td>2. FAG Bearing India Ltd.</td>
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<td>3. NTN Bearings</td>
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**Skirt Boards**

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<td>1. TEGA India Ltd.</td>
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<td>2. Kaveri ultra-polymers Ltd.</td>
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**External Belt Cleaner**

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**Continuous Belt Weigher**

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<td>2. Transweigh India Ltd.</td>
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</tr>
<tr>
<td>3. Power Engg Co</td>
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<td>4. Weitex India limited</td>
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**Electric Hoists**

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<td>2. Greaves Ltd.</td>
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</tr>
<tr>
<td>3. Hercules Hoists Ltd.</td>
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</tr>
<tr>
<td>4. W.H. Brady &amp; Co. Ltd</td>
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**E.O.T Cranes**

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<td>1. W.H. Brady &amp; Co. Ltd</td>
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<td>2. Avon Cranes Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>3. The ACME manufacturing Co. Ltd</td>
<td>India</td>
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<tr>
<td>4. WMI Cranes</td>
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<td>5. Samco Engineering Pvt. Ltd</td>
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**Screw Conveyor**

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<td>1. Elecon Engg. Co. Ltd</td>
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</table>
2. Tecpro system limited  
3. Indiana conveyor  

**Metal Separator**  
1. Magnet India  
2. Electro zaved  
3. Krupp  

**Chain Pulley Blocks / Chain Hoists**  
1. Hercules Hoists Ltd.  
2. W.H. Brady & Co. Ltd  
3. Mangla Hoist & Hydraulics Ltd.  
4. Tractel Tirfor india Pvt. Ltd.  

### 7.0 INSTRUMENTATION:

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<tr>
<th>Sl.No</th>
<th>Vendor’s Name</th>
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<tbody>
<tr>
<td><strong>Gas Analysers (IR, Thermal Conductivity, Paramagnetic)</strong></td>
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<tr>
<td>1.</td>
<td>ABB Ltd (BU – Analytical &amp;Adv)</td>
<td>India</td>
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<tr>
<td>2.</td>
<td>Chemtrons Industries Limited (Maihak Make)</td>
<td>India</td>
</tr>
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<td>3.</td>
<td>Emerson Process Management (I) Pvt. Ltd</td>
<td>India</td>
</tr>
<tr>
<td>4.</td>
<td>Endress+ Hauser (India) Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>5.</td>
<td>Yokagawa</td>
<td>India</td>
</tr>
<tr>
<td>6.</td>
<td>Ametek ,INC</td>
<td>U.S.A</td>
</tr>
<tr>
<td>7.</td>
<td>Emerson Process Mgt Singapore Ltd.</td>
<td>Singapore</td>
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<td>8.</td>
<td>MaihakAktiengesellschaft</td>
<td>Germany</td>
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<td>9.</td>
<td>M.S.A International</td>
<td>U.S.A</td>
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<td>10.</td>
<td>Siemens AG</td>
<td>Germany</td>
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<td><strong>Sodium Analyser</strong></td>
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<td>1.</td>
<td>ABB</td>
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</tr>
<tr>
<td>2.</td>
<td>HACH</td>
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<tr>
<td>3.</td>
<td>THERMOFISHER</td>
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<tr>
<td>4.</td>
<td>WALTRON</td>
<td></td>
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<tr>
<td>5.</td>
<td>AWA</td>
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<tr>
<td><strong>Chlorine Analyser</strong></td>
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<td>1.</td>
<td>ABB</td>
<td>INDIA</td>
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<td>2.</td>
<td>HACH</td>
<td>FRANCE</td>
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<td>3.</td>
<td>KROHNE</td>
<td>U.K</td>
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<td>E&amp;H</td>
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<td>WALTRON</td>
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<td>6.</td>
<td>THERMOFISHER</td>
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<td><strong>Turbidity Analyser</strong></td>
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<td>JAPAN</td>
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<td><strong>pH, conductivity &amp; ORP Analyser</strong></td>
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<td>ABB India Limited</td>
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<td>BELA INSTRUMENTS (For Knick, GmbH make), Mumbai(For</td>
<td>India</td>
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<td>Vendor List</td>
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<td>4</td>
<td>Emerson Process Management (I) Pvt. Ltd</td>
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<td>5</td>
<td>Endress+Hauser (India) Pvt. Ltd (Liquid Analyzer)</td>
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<td>6</td>
<td>Forbes polymetrin Pvt. Ltd.</td>
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<td>7</td>
<td>POTENCE CONTROLS (for GLI International make), Mumbai (For Conductivity Analyzer)</td>
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<td>8</td>
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<td>9</td>
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<td>11</td>
<td>Hach Company</td>
<td>U.S.A</td>
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<td>12</td>
<td>Yokogawa Electric Corporation</td>
<td>Japan</td>
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<td>13</td>
<td>Zellweger SA</td>
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**Trace Analyzer/ Ion Selective**

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<tr>
<th>Vendor List</th>
<th>Product Description</th>
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<tbody>
<tr>
<td>1</td>
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<td>2</td>
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<td>3</td>
<td>Forbes Polymetrin Pvt. Ltd.</td>
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<tr>
<td>4</td>
<td>Bran &amp;Luebbe Ltd</td>
</tr>
<tr>
<td>5</td>
<td>Hach Company</td>
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<td>6</td>
<td>Zellweger SA</td>
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**PC / SERVERS**

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**Fire Alarm System**

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<td>2</td>
<td>SIEMENS</td>
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**SO₂/NOₓ Analyzer**

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<th>Product Description</th>
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<td>4</td>
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<td>Emerson Process Management Singapore Ltd</td>
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<td>Horiba Ltd.</td>
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<td>Lear Siegler Meas. Controls Corp.</td>
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**Mass Spectrometer**

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**Gas Chromatograph**

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<td>3</td>
<td>Applied Automation Inc</td>
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<td>4</td>
<td>ABB Process Analytics</td>
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<td>5</td>
<td>Foxbar Far East Pte Ltd</td>
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<td>6</td>
<td>Siemens</td>
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<td>7</td>
<td>Yokogawa India Ltd.</td>
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**Flue Gas Analyzer (ZrO₂ type)**
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<th>Company Name</th>
<th>Country</th>
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<td>1.</td>
<td>ABB Ltd (BU – Analytical &amp;Adv)</td>
<td>India</td>
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<td>Chemtrol (For MAIHAK Only)</td>
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<td>Endress+Hauser</td>
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<td>5.</td>
<td>Yokogawa India Ltd.</td>
<td>India</td>
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<tr>
<td>6.</td>
<td>Ametek Inc</td>
<td>U.S.A</td>
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<td>7.</td>
<td>GE Panametrics</td>
<td>Ireland</td>
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**H<sub>2</sub>S/ Total Sulphur Analysers**

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**System House Analysers**

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<td>2.</td>
<td>Adage Automation Pvt. Ltd.</td>
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<td>3.</td>
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<td>4.</td>
<td>Chemtrols Industries Limited</td>
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<tr>
<td>5.</td>
<td>Emerson Process Management (I) Pvt. Ltd</td>
<td>India</td>
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<tr>
<td>6.</td>
<td>Yokogawa India Ltd.</td>
<td>India</td>
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<tr>
<td>7.</td>
<td>Intech</td>
<td>Italy</td>
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**Density Analysers**

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<td>1.</td>
<td>Chemtrols Industries Limited</td>
<td>India</td>
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<tr>
<td>2.</td>
<td>Emerson Process Management (I) Pvt. Ltd (coriolis type)</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>Bopp &amp; Reuther MesstechnikGmbh (coriolis type)</td>
<td>Germany</td>
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<tr>
<td>4.</td>
<td>Solartron Mobrey</td>
<td>U.K</td>
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**Moisture Analysers**

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<tbody>
<tr>
<td>1.</td>
<td>Chemtrols Industries Limited</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>Ametek Inc</td>
<td>U.S.A</td>
</tr>
<tr>
<td>3.</td>
<td>GE Panametrics</td>
<td>Italy</td>
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**Gas & Fire Detection System**

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<th>Company Name</th>
<th>Country</th>
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<td>Andrew Yule &amp; Company Ltd. (Fire)</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>Chemtrols Industries Limited</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>Honeywell Automation India Limited (Gas)</td>
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</tr>
<tr>
<td>4.</td>
<td>J B Boda And Brothers Pvt. Ltd. (Gas Make-International Sensor Technology)</td>
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<tr>
<td>5.</td>
<td>Pollution Protection System Mumbai Pvt Ltd (Gas)</td>
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<tr>
<td>6.</td>
<td>General Monitors (Gas)</td>
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<td>7.</td>
<td>Teledyne Fluid Systems (Gas)</td>
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**Air Quality Monitoring System**

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**Sample Handling System**

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<td>1.</td>
<td>Analyser Instrument Co.Pvt. Ltd.</td>
<td>India</td>
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</table>

**Flow Element: Orifice/ Venturi/ Flow Nozzle**

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<th>Company Name</th>
<th>Country</th>
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<td>India</td>
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<tr>
<td>2.</td>
<td>Chemtrol Industries Ltd.</td>
<td>India</td>
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<tr>
<td>3.</td>
<td>Delta Engineering, Pune</td>
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<td>4.</td>
<td>Eureka Industrial Equipments Pvt. Ltd.</td>
<td>India</td>
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<td>5.</td>
<td>FORBES MARSHALL</td>
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<tr>
<td>6.</td>
<td>Flowtech Instruments (Orifice/Venturi)</td>
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<td>7.</td>
<td>General Instruments Consortium</td>
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<td>8.</td>
<td>Instrumentation Ltd.</td>
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<td>9.</td>
<td>Micro Precision Products Private Ltd.</td>
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<td>10.</td>
<td>Micro India Flow Elements Pvt. Ltd.</td>
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<td>11.</td>
<td>Minco(India) Flow Instruments Pvt. Ltd.</td>
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<td>Unicontrols Instrument Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>13</td>
<td>Bopp &amp; Reuther Messtechnik GMBH</td>
<td>Germany</td>
</tr>
<tr>
<td>14</td>
<td>Daniel Measurement &amp; Control</td>
<td>USA</td>
</tr>
<tr>
<td>15</td>
<td>ISA Controls Limited</td>
<td>U.K.</td>
</tr>
<tr>
<td>16</td>
<td>Technomatic SPA</td>
<td>Italy</td>
</tr>
</tbody>
</table>

**Pitot Tube/Annubar**

| 1   | ABB India Limited | India |
| 2   | Control Engineers  | India |
| 3   | Emerson Process Management (I) Pvt. Ltd. | India |
| 4   | Micro Precision Products Private Ltd. | India |
| 5   | Unicontrols Instruments Pvt. Ltd. | India |
| 6   | Daniel Measurement & Control | U.S.A |
| 7   | ISA Controls Limited | U.K. |
| 8   | Technomatic Spa | Italy |

**Rotameters**

| 1   | ABB India Ltd. | India |
| 2   | Chemtrols Industries Ltd. | India |
| 3   | Delta Control | India |
| 4   | Eureka Industrial Equipments Pvt. Ltd. | India |
| 5   | Flowtech Instruments services | India |
| 6   | Instrumentation Engineers Pvt. Ltd. | India |
| 7   | Krohne Marshall Pvt. Ltd. | India |
| 8   | Placka Instruments & Controls Pvt. Ltd. (Purge Rotameter Only) | India |
| 9   | Rota Instrumentation | India |
| 10  | Yokogawa | India |
| 11  | Rota Yokogawa Gmbh & Co. Kg | Germany |
| 12  | Tokyo Keiso Co.Ltd. | Japan |
| 13  | Azbil Corporation | Japan |
| 14  | Emerson Process Mgt | U.S.A |
| 15  | Krohne | Germany |

**Mass Flow Meter (Coriolis Type)**

| 1   | ABB India Limited | India |
| 2   | Chemtrol Industries Ltd | India |
| 3   | Emerson Process Management (I) Pvt. Ltd. | India |
| 5   | Endress + Hauser | India |
| 6   | SIEMENS Ltd. | India |
| 7   | Yokogawa | India |
| 8   | Bopp & Reuther Messtechnik GMBH | Germany |
| 7   | Krohne | Germany |
| 8   | Schlumberger resource management Ltd. | U.S.A |

**Turbine Flowmeter**

<p>| 1   | ABB India Ltd. | India |
| 2   | Chemtrol Industries Ltd | India |
| 3   | Krohne | India |
| 4   | Yokogawa | India |
| 5   | Azbil Corporation | Japan |
| 6   | Bopp &amp; Reuther Messtechnik Gmbh | Germany |
| 7   | Barton Instrument System Ltd. | U.K. |
| 8   | Emerson Process Mgt | U.K. |
| 9   | Emerson Process Mgt. | U.S.A |
| 10  | Instromet International N.V. | Holland |</p>
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<tr>
<th></th>
<th>Vendor Name</th>
<th>Country</th>
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<td>11</td>
<td>Itochu Corporation</td>
<td>Japan</td>
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<tr>
<td>12</td>
<td>Oval Asea Pacific Pte Ltd.</td>
<td>Singapore</td>
</tr>
<tr>
<td>13</td>
<td>Rockwell International Corporation</td>
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**Vortex meter**

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<tr>
<td>3</td>
<td>Krohne Marshall Pvt. Ltd.</td>
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<tr>
<td>4</td>
<td>Siemens Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>5</td>
<td>Yokogawa Limited</td>
<td>India</td>
</tr>
<tr>
<td>6</td>
<td>Bopp &amp; Reuther MesstechnikGmbh</td>
<td>Germany</td>
</tr>
<tr>
<td>7</td>
<td>Endress + Hauser</td>
<td>Germany</td>
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<tr>
<td>8</td>
<td>Itochu Corporation</td>
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</tr>
<tr>
<td>9</td>
<td>Krohne</td>
<td>Germany</td>
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<tr>
<td>10</td>
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**PD Meter**

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<td>U.S.A</td>
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<td>5</td>
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**Magnetic Flow meter**

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<td>Krohne Marshall Pvt. Ltd.</td>
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<td>6</td>
<td>Siemens Ltd.</td>
<td>India</td>
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<td>7</td>
<td>SBEM Pvt. Ltd.</td>
<td>India</td>
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<td>8</td>
<td>Yokogawa</td>
<td>India</td>
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<tr>
<td>9</td>
<td>Azbil Corporation</td>
<td>Japan</td>
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<tr>
<td>10</td>
<td>Bopp &amp; Reuther MesstechnikGmbh</td>
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**Insertion Type Flow Meter**

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<tr>
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<td>Siemens Ltd.</td>
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**Ultrasonic Flow Meter**

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<td>Endress + Hauser (India) Pvt. Ltd.</td>
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<td>3</td>
<td>Emerson Process Management</td>
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<tr>
<td>4</td>
<td>Siemens Ltd.</td>
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<td>5</td>
<td>Yokogawa</td>
<td>India</td>
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**Orifice Meter**

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**Metering Skid**

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**Pressure Gauges**

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<th>Vendor Name</th>
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<tr>
<td>1</td>
<td>Ashcroft India(P) Ltd. (standard normal type)</td>
<td>India</td>
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<tr>
<td>2</td>
<td>A.N. Instruments Pvt. Ltd.</td>
<td>India</td>
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<tr>
<td>3</td>
<td>Baumer Technologies India Pvt. Ltd</td>
<td>India</td>
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<td>4</td>
<td>Forbes Marshall</td>
<td>India</td>
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<td></td>
<td>Company Name</td>
<td>Country</td>
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<tr>
<td>5</td>
<td>General Instruments Consortium,</td>
<td>India</td>
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<tr>
<td>6</td>
<td>H.Guru Industries</td>
<td>India</td>
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<tr>
<td>7</td>
<td>Peejee Engg. Works</td>
<td>India</td>
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<tr>
<td>8</td>
<td>Precision Industries Ltd. (standard normal type)</td>
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<td>9</td>
<td>Premium Instrument &amp; Controls Ltd.</td>
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<td>Manometer (India) Pvt. Ltd.</td>
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<td>Walchand Nagar Industries Ltd.</td>
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<td>12</td>
<td>Wika</td>
<td>India</td>
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<td>13</td>
<td>Budenberg Gauge Co. Ltd</td>
<td>U.K</td>
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<td>14</td>
<td>Dresser Europe S.A</td>
<td>Germany</td>
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<td>15</td>
<td>Nagano keiki Seisakusho</td>
<td>Japan</td>
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<td>Rueger Sa</td>
<td>Switzerland</td>
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<td>17</td>
<td>Spriano Spa</td>
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<tr>
<td>18</td>
<td>WikaAlexenderWiegardGmbh&amp; Co.</td>
<td>Germany</td>
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**Local D/P Indicators**

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<tr>
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<th>Company Name</th>
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<tbody>
<tr>
<td>1</td>
<td>Precision Mass Products Pvt. Ltd</td>
<td>India</td>
</tr>
<tr>
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<td>Switzer Instrument Co.</td>
<td>India</td>
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<tr>
<td>3</td>
<td>Wika</td>
<td>India</td>
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<tr>
<td>4</td>
<td>Barton Instrument Systems Limited</td>
<td>U.K</td>
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<tr>
<td>5</td>
<td>Delta Controls Ltd.</td>
<td>U.K</td>
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**Pressure & D/P Transmitters**

<table>
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<tr>
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<td>ABB India Ltd.</td>
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<td>2</td>
<td>Emerson Process Management (I) Pvt. Ltd.</td>
<td>India</td>
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<tr>
<td>3</td>
<td>Endress + Hauser (India) Pvt.Ltd.</td>
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<tr>
<td>4</td>
<td>Honeywell Automation India Limited</td>
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<td>5</td>
<td>Siemens Ltd.</td>
<td>India</td>
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<td>6</td>
<td>Yokogawa Limited</td>
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<tr>
<td>7</td>
<td>Azbil Corporation</td>
<td>Japan</td>
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<tr>
<td>8</td>
<td>Emerson Process Mgt Singapore Ltd</td>
<td>Singapore</td>
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<tr>
<td>9</td>
<td>Honeywell Inc.</td>
<td>U.S.A</td>
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<td>Moore Products Company</td>
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<td>Siemens Ag, Germany</td>
<td>Germany</td>
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<td>12</td>
<td>Smar Singapore Pte. Ltd.</td>
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<td>13</td>
<td>VEGA Griehaber KG</td>
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<td>14</td>
<td>Yokogawa Electric Corporation</td>
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**Pressure & D/P Switches Including Vol. Seal**

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<td>3</td>
<td>Kaustubha Udyog (Except Vol.Seal)</td>
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<tr>
<td>4</td>
<td>Precision Mass Products Pvt. Ltd</td>
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<td>5</td>
<td>Switzer Instrument Co. (Except Vol.Seal)</td>
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<td>6</td>
<td>Azbil Corporation</td>
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<tr>
<td>7</td>
<td>Delta Controls Ltd.</td>
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<td>8</td>
<td>Nagano Keiki Seisakusho</td>
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<tr>
<td>9</td>
<td>SOR Inc.</td>
<td>U.S.A</td>
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<td>United Electric Controls Co.</td>
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**Transparent/ Reflex / Bicolor Mag.Level Gauges**

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<td>Bliss Anand Private Ltd.</td>
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<tr>
<td>3</td>
<td>Chemtrols Samil(India) Pvt Ltd.</td>
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</tr>
<tr>
<td>4</td>
<td>Flowtech Instruments services</td>
<td>India</td>
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</table>
5. LEVCON INSTRUMENTS PVT. LTD. INDIA
6. Nisan Scientific Process Equipments Pvt. Ltd India
7. Pune Techtrl Pvt. Ltd. (=<300#) India
8. Technomatic (India) Pvt. Ltd. India
9. V-Automat Instruments Pvt. Ltd. (upto 300#) India
10. Clark-Reliance Corp. U.S.A
11. CesareBonetti Italy
12. Jerugson Gauge & Valve Co. U.S.A
13. Nihon Klingage Co. Ltd. Japan
14. Richard Klinger Ag Austria
15. Technomatic Spa Italy

**Level Switches (Float & Displacer Type)**

1. ABB India Ltd. India
2. Bliss Anand Private Ltd. India
3. Chemtrols Samil(India) Pvt Ltd. India
4. Pune Techtrl Pvt. Ltd. India
5. SBEM Pvt. Ltd. India
6. Siemens Ltd. India
7. V.Automat & Instruments (P) Ltd. India
8. ISA Controls Limited U.K.
9. KDG. MOBREY Ltd. U.K.
10. Magnetrol International N.V Belgium
11. SOR Inc. U.S.A
12. Vega Grieshaber KG Germany

**Displacer Type Level Transmitters**

1. Chemtrols Industries Limited (Eckdart Make Electronics) India
2. Dresser Valve India Pvt Ltd (Rating <= 600#) India
3. Dresser Masoneilan France
4. Foxboro EckardtGmbh Germany
5. Magnetrol International N.V. (Lvdt) Belgium
6. Parcol Spa (Pneumatic Transmission Only) Italy

**Tank Level Instruments**

1. ABB India Limited India
2. Emerson Process Management (i) Pvt. Ltd. India
3. Pune Techtrl Pvt. Ltd. India
4. Siemens Ltd. (Radar level Transmitter, guided wave Radar) India
5. SBEM Pvt. Ltd. India
7. Endress + Hauser Gmbh& Co., (Non-Contact & Servo) Germany
8. Krohne (Non-Contact Type) Germany
9. L& J Technologies U.S.A
10. Toyo Keiso Co. Ltd. Japan

**Ultrasonic Level Transmitter**

1. Forbes Marshell India
2. Siemens Ltd. India
3. Vega Grieshaber KG Germany

**Tank Farm Management**

1. Endress + Hauser (India) Pvt. Ltd. (Servo,Radar) India

**Guided wave Radar**

1. Endress + Hauser (India) Pvt. Ltd India
2. Forbes Marshell India
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<th>Product</th>
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<td>W.C. Heraeus GMBH</td>
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<td><strong>Bimetallic Thermometer</strong></td>
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<td>Baumer Technologies India Pvt. Ltd.</td>
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<td>H.Guru Industries</td>
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<td>7.</td>
<td>Krohne Marshall Pvt. Ltd.</td>
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<td>8.</td>
<td>Precision Mass Products Pvt. Ltd.</td>
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<td>9.</td>
<td>Nagano Keiki Seisakusho</td>
<td>Japan</td>
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<tr>
<td>10.</td>
<td>Rueger SA</td>
<td>Switzerland</td>
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<td>11.</td>
<td>Technomatic SPA</td>
<td>Italy</td>
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</tr>
<tr>
<td>12.</td>
<td>Trend Instrument Inc.</td>
<td>U.S.A</td>
<td></td>
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<tr>
<td></td>
<td><strong>Vibration Fork type Level Switches</strong></td>
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<tr>
<td>1.</td>
<td>ABB India Ltd.</td>
<td>India</td>
<td></td>
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<tr>
<td>2.</td>
<td>Protocontrol Instruments (I) Pvt. Ltd. (non-critical)</td>
<td>India</td>
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</tr>
<tr>
<td>3.</td>
<td>Endress + Hauser</td>
<td>Germany</td>
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<td>4.</td>
<td>SOR Inc.</td>
<td>U.S.A</td>
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<td></td>
<td><strong>Dial Thermometer (Hg In Steel/Glass)</strong></td>
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<tr>
<td>1.</td>
<td>A N Instruments Pvt. Ltd.</td>
<td>India</td>
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<tr>
<td>2.</td>
<td>Ashcroft India(P) Ltd.</td>
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<tr>
<td>3.</td>
<td>Baumer Technologies India Pvt. Ltd.</td>
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<tr>
<td>4.</td>
<td>General Instruments Consortium</td>
<td>India</td>
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<tr>
<td>5.</td>
<td>Goa Instruments Industries Ltd.</td>
<td>India</td>
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<tr>
<td>6.</td>
<td>H.Guru Industries</td>
<td>India</td>
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<td>7.</td>
<td>Precision Mass Products Pvt. Ltd.</td>
<td>India</td>
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<td>8.</td>
<td>Pejee Engg Works</td>
<td>India</td>
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<td>9.</td>
<td>Walchand Nagar Industries Ltd.</td>
<td>India</td>
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## Radiation Pyrometer

<table>
<thead>
<tr>
<th>No.</th>
<th>Supplier</th>
<th>Country</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tempsens Instruments Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>C.C.R Technico</td>
<td>Italy</td>
</tr>
<tr>
<td>3.</td>
<td>Chino Corp.</td>
<td>Japan</td>
</tr>
<tr>
<td>4.</td>
<td>Land Infrared</td>
<td>U.K.</td>
</tr>
<tr>
<td>5.</td>
<td>Siemens AG</td>
<td>Germany</td>
</tr>
<tr>
<td>6.</td>
<td>Wahal Instruments</td>
<td>U.S.A</td>
</tr>
</tbody>
</table>

## Temperature Transmitters

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<th>No.</th>
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<tbody>
<tr>
<td>1.</td>
<td>ABB India Limited</td>
<td>India</td>
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<tr>
<td>2.</td>
<td>Emerson Process</td>
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<tr>
<td>3.</td>
<td>Endress+ Hauser (India) Pvt. Ltd.</td>
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</tr>
<tr>
<td>4.</td>
<td>Siemens Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>5.</td>
<td>Yokogawa</td>
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</table>

## Gate/Plug Valves

<table>
<thead>
<tr>
<th>No.</th>
<th>Supplier</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Audco India Limited (L&amp;T Valves Divn.)</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>BHEL (Valves Division)</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>Chemtrols Engineering Limited (Plug Valves)</td>
<td>India</td>
</tr>
<tr>
<td>4.</td>
<td>Flowserve India Control Pvt. Ltd. (Plug Valve upto 12&quot; 300# upto 6&quot; 600#)</td>
<td>India</td>
</tr>
<tr>
<td>5.</td>
<td>Ksb Pumps Limited (Valves Divn)</td>
<td>India</td>
</tr>
<tr>
<td>6.</td>
<td>NU Tech Controls (MOV Gate: 1/2&quot; to 8&quot; 2500#, 10&quot; to 14&quot;, 300#)</td>
<td>India</td>
</tr>
<tr>
<td>7.</td>
<td>Samsons Controls Pvt. Ltd. (Upto 34&quot;, 300#)</td>
<td>India</td>
</tr>
<tr>
<td>8.</td>
<td>Valve Tech Industries (Mov -8&quot; upto 2500#)</td>
<td>India</td>
</tr>
<tr>
<td>9.</td>
<td>Velan Inc.</td>
<td>Canada</td>
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<tr>
<td>10.</td>
<td>Weir Bdk Valves</td>
<td>India</td>
</tr>
<tr>
<td>11.</td>
<td>Bel Valves</td>
<td>Japan</td>
</tr>
<tr>
<td>12.</td>
<td>Cesare Bonetti</td>
<td>Italy</td>
</tr>
<tr>
<td>13.</td>
<td>Fasani S.P.A</td>
<td>Italy</td>
</tr>
<tr>
<td>14.</td>
<td>Malbranque S.A.</td>
<td>France</td>
</tr>
<tr>
<td>15.</td>
<td>Matsura H. P Machine works co. Ltd.</td>
<td>Japan</td>
</tr>
<tr>
<td>16.</td>
<td>Petrol Valves S.R.L</td>
<td>Italy</td>
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## Globe / Angle Valves

<table>
<thead>
<tr>
<th>No.</th>
<th>Supplier</th>
<th>Country</th>
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<tbody>
<tr>
<td>1.</td>
<td>AST S.P.A (Upto 8&quot; 900#)</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>Chemtrol Industries Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>Circor Flow Technologies India Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>4.</td>
<td>Dresser Valve India Pvt. Ltd. (Rating =&lt;600#, size 1/4&quot; to 6&quot;)</td>
<td>India</td>
</tr>
<tr>
<td>5.</td>
<td>Emerson Process Management India Ltd</td>
<td>India</td>
</tr>
<tr>
<td>6.</td>
<td>Emet Controls Pvt. Ltd. (Globe Valve up to 4&quot;, 300# angle valve upto 1-1/2&quot;, 2500#)</td>
<td>India</td>
</tr>
<tr>
<td>7.</td>
<td>Flowserve india control pvt. Ltd. (globe valve upto 30&quot; 600# upto 24&quot; 900#, upto 16&quot; 2500# upto 4&quot; 4500#)</td>
<td>India</td>
</tr>
<tr>
<td>8.</td>
<td>Koso fluids controls pvt. Ltd. (globe valves: upto 8&quot; 2500# 10 to 18&quot; 300# angle valves upto 8&quot; 300#)</td>
<td>India</td>
</tr>
<tr>
<td>9.</td>
<td>Instrumentation Ltd. (Palakkad)</td>
<td>India</td>
</tr>
<tr>
<td>10.</td>
<td>Mil Controls Limited</td>
<td>India</td>
</tr>
<tr>
<td>11.</td>
<td>NU Tech Controls</td>
<td>India</td>
</tr>
<tr>
<td>12.</td>
<td>Pneucon valves Pvt. Ltd. (upto 6&quot; 300#) noncritical)</td>
<td>India</td>
</tr>
<tr>
<td>13.</td>
<td>Samson Control Pvt Ltd (upto 6&quot; &amp; &lt;=600#)</td>
<td>India</td>
</tr>
<tr>
<td>14.</td>
<td>Tecnik valves pvt Ltd. (air &amp; water service upto 4&quot; 150#)</td>
<td>India</td>
</tr>
<tr>
<td>15.</td>
<td>Valve-Tech Industries (non-critical)</td>
<td>India</td>
</tr>
<tr>
<td>16.</td>
<td>Azbil Corporation (=&lt; 2500#)</td>
<td>Japan</td>
</tr>
<tr>
<td>17.</td>
<td>Arca Regler GMBH</td>
<td>Germany</td>
</tr>
<tr>
<td>No.</td>
<td>Vendor Name</td>
<td>Country</td>
</tr>
<tr>
<td>-----</td>
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</tr>
<tr>
<td>17</td>
<td>Dresser Masoneilan</td>
<td>France</td>
</tr>
<tr>
<td>18</td>
<td>Flowserve (&lt;=2500#)</td>
<td>U.S.A</td>
</tr>
<tr>
<td>19</td>
<td>Fisher Xomox (&lt;= 2500#)</td>
<td>Singapore</td>
</tr>
<tr>
<td>20</td>
<td>Parcol Spa</td>
<td>Italy</td>
</tr>
<tr>
<td>21</td>
<td>Nippon Fisher Co. Ltd. (&lt;=2500#)</td>
<td>Japan</td>
</tr>
<tr>
<td>22</td>
<td>Severn Glocon (1 to 12“600#)</td>
<td>U.K.</td>
</tr>
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</table>

### Ball Valves

<table>
<thead>
<tr>
<th>No.</th>
<th>Vendor Name</th>
<th>Country</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Tyco Valves &amp; Controls (I) Ltd (&lt;= 150#)</td>
<td>India</td>
</tr>
<tr>
<td>2</td>
<td>Virgo Engineers Ltd. (&lt;=600# With Maccair Actuators)</td>
<td>India</td>
</tr>
<tr>
<td>3</td>
<td>Anand teknov aids engineering india limited (upto 6”,600# (ON-OFF))</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>Bray Controls India Pvt. Ltd.(upto 4”,300#)</td>
<td>India</td>
</tr>
<tr>
<td>5</td>
<td>Emerson</td>
<td>India</td>
</tr>
<tr>
<td>6</td>
<td>EMET controls pvt. Ltd. (upto 8”,150# for air service)</td>
<td>India</td>
</tr>
<tr>
<td>7</td>
<td>Fisher Xomox Sanmar</td>
<td>India</td>
</tr>
<tr>
<td>8</td>
<td>Flowserve India controls Pvt. Ltd. ( upto 16” 600# )</td>
<td>India</td>
</tr>
<tr>
<td>9</td>
<td>Intervalve ponnawalla limited (uptp 10”,150#)</td>
<td>India</td>
</tr>
<tr>
<td>10</td>
<td>Koso Fluid Controls Pvt. Ltd. ( upto 8 ”,2500#, 10” to 18” 900# )</td>
<td>India</td>
</tr>
<tr>
<td>11</td>
<td>NU Tech Controls (14”,600# for non-critical purpose)</td>
<td>India</td>
</tr>
<tr>
<td>12</td>
<td>Pentair Valves and controls India Pvt. Ltd. (&lt;=150#)</td>
<td>India</td>
</tr>
<tr>
<td>13</td>
<td>Pneucon valves pvt. Ltd. (upto 6”,150# non-critical)</td>
<td>India</td>
</tr>
<tr>
<td>14</td>
<td>Samson Control Pvt Ltd(upto 24” &amp;&lt;1500#)</td>
<td>India</td>
</tr>
<tr>
<td>15</td>
<td>Valve tech industries ltd. (18”,150# non critical)</td>
<td>India</td>
</tr>
<tr>
<td>16</td>
<td>Weir Bdk Vlaves (upto 16”,150#)</td>
<td>India</td>
</tr>
<tr>
<td>17</td>
<td>G.T.C. Italia S.R.L(&lt;=300#)</td>
<td>Italy</td>
</tr>
<tr>
<td>18</td>
<td>Metso Automation (=&lt;2500#)</td>
<td>Singapore</td>
</tr>
<tr>
<td>19</td>
<td>Orbit Valves PLC (=&lt;2500#)</td>
<td>Singapore</td>
</tr>
<tr>
<td>20</td>
<td>Petrol Valves S.R.L</td>
<td>Italy</td>
</tr>
<tr>
<td>21</td>
<td>PERRIN Gmbh (size ½” to 12”,&amp; rating 150# to 2500#,size 14”to 18”, rating 150# to 1500#, size 20”to 24” rating 150# &amp; 300#)</td>
<td>Germany</td>
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<tr>
<td>22</td>
<td>Pibiviesse S.P.A. (Rating Upto 2500 #)</td>
<td>Italy</td>
</tr>
<tr>
<td>23</td>
<td>Rotex manufacturers &amp; Engineers Pvt. Ltd. (upto 6” 600#, 6” to 10” 150#)</td>
<td>India</td>
</tr>
<tr>
<td>24</td>
<td>Velan Inc. ( ball valves on/off size: ½” to 6” (rating upto 2500#) size 8”to 16” (rating upto 900#) size 18” to 30 “ (rating upto 300#)</td>
<td>Canada</td>
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### Butterfly Valves

<table>
<thead>
<tr>
<th>No.</th>
<th>Vendor Name</th>
<th>Country</th>
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<tbody>
<tr>
<td>1</td>
<td>Advance valves pvt. Ltd.(size 2”to 24” upto 600#)</td>
<td>India</td>
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<tr>
<td>2</td>
<td>Bray controls india Pvt. Ltd. ( upto 300#)</td>
<td>India</td>
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<tr>
<td>3</td>
<td>Dresser Masonelian Valves</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>Emet controls pvt. Ltd. (upto 4”,900#, 6”,150# to 16”,150# double eccentric )</td>
<td>India</td>
</tr>
<tr>
<td>5</td>
<td>Flowserve india control pvt. Ltd. ( upto 30”,300# upto 12” 600#)</td>
<td>India</td>
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<tr>
<td>6</td>
<td>Fisher</td>
<td>India</td>
</tr>
<tr>
<td>7</td>
<td>Intervalve ponnawaala ltd. (2” to 48”,150#)</td>
<td>India</td>
</tr>
<tr>
<td>8</td>
<td>Instrumentation Ltd. (Palakkad) (&lt;= 300#)</td>
<td>India</td>
</tr>
<tr>
<td>9</td>
<td>Koso fluid controls (pvt. ) ltd. (&lt;= 150#)</td>
<td>India</td>
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<tr>
<td>10</td>
<td>Nu tech controls (16”,300# for non-critical services )</td>
<td>India</td>
</tr>
<tr>
<td>11</td>
<td>Pneucon valves pvt. Ltd. (upto 8”,150# non critical )</td>
<td>India</td>
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<tr>
<td>12</td>
<td>Samson controls pvt. Ltd.</td>
<td>India</td>
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<tr>
<td>13</td>
<td>Tyco Valves &amp; Controls (I) Ltd (&lt;= 150 #)</td>
<td>India</td>
</tr>
<tr>
<td>14</td>
<td>Valve tech industries ( non-critical services)</td>
<td>India</td>
</tr>
<tr>
<td>15</td>
<td>Virgo Engineers Ltd. (=&lt;300#)</td>
<td>India</td>
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<tr>
<td>16</td>
<td>Weird BDK valves (upto 16”,300#0</td>
<td>India</td>
</tr>
<tr>
<td>17</td>
<td>Bray Controls(&lt;=300#)</td>
<td>U.S.A</td>
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<tr>
<td>No.</td>
<td>Vendor Name</td>
<td>Country</td>
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<td>-----</td>
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</tr>
<tr>
<td>18</td>
<td>Keystone (Upto 2500#)</td>
<td>Singapore</td>
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<td>19</td>
<td>Leeds Valve ltd.</td>
<td>UK</td>
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<tr>
<td>20</td>
<td>Korea Unicom Valve Co. Ltd.</td>
<td>Korea</td>
</tr>
<tr>
<td>21</td>
<td>Parcol Spa (&lt;= 2500# Urea Service Also)</td>
<td>Italy</td>
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<tr>
<td>22</td>
<td>Pentair Valves and controls India Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>23</td>
<td>Metso Automation (Upto 2500#)</td>
<td>Singapore</td>
</tr>
<tr>
<td>24</td>
<td>Orton S.r.l. (upto 2500#)</td>
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</table>

**PRDS & SPRAY NOZZLE, VENT VALVES upto 2500#**

<table>
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<tr>
<th>No.</th>
<th>Vendor Name</th>
<th>Country</th>
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</thead>
<tbody>
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<td>ARCA (Forbes Marshal) (Mech. Spray nozzle type desuperheater only)</td>
<td>India</td>
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<tr>
<td>2</td>
<td>Chemtrols Industries Ltd. (PRDS Combine &amp; Split)</td>
<td>India</td>
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<tr>
<td>3</td>
<td>Circor Flow Technologies India Pvt. Ltd. (1&quot; to 20&quot;, upto 150#, 1 to 10&quot; upto 1500#, 1&quot; to 8&quot;, upto 2500#)</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>Control components INC</td>
<td>India</td>
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<tr>
<td>5</td>
<td>Fisher Controls</td>
<td>India</td>
</tr>
<tr>
<td>6</td>
<td>Samson Controls Pvt. Ltd. (upto 6&quot;, 150#)</td>
<td>India</td>
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<tr>
<td>7</td>
<td>CCI Valve Technology AB</td>
<td>Sweden</td>
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<tr>
<td>8</td>
<td>SPX Valves &amp; Controls (COPES-VULCAN LTD.)</td>
<td>U.S.A</td>
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</table>

**Electric Actuator**

<table>
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<th>No.</th>
<th>Vendor Name</th>
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<td>1</td>
<td>Biffi Italia S.R.L</td>
<td>Italy</td>
</tr>
<tr>
<td>2</td>
<td>Limitorque, U.S.A</td>
<td>U.S.A</td>
</tr>
<tr>
<td>3</td>
<td>Rotork Control (Deutschland) GmbH</td>
<td>Germany</td>
</tr>
<tr>
<td>4</td>
<td>Auma, Usa</td>
<td>U.S.A</td>
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</table>

**Air Filter cum Pressure Regulator**

<table>
<thead>
<tr>
<th>No.</th>
<th>Vendor Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ABB India Limited</td>
<td>India</td>
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<tr>
<td>2</td>
<td>Divya Control Elements Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>3</td>
<td>Dresser</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>Emerson Process Management</td>
<td>India</td>
</tr>
<tr>
<td>5</td>
<td>Mil Controls Limited</td>
<td>India</td>
</tr>
<tr>
<td>6</td>
<td>Placka Instruments &amp; Controls Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>7</td>
<td>Shavo Norgren (India) Pvt Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>8</td>
<td>Schrader Duncan Ltd. (1/4&quot; to 2&quot; port size)</td>
<td>India</td>
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</tbody>
</table>

**Valve Actuator (Pneumatic/Rotary)**

<table>
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<th>No.</th>
<th>Vendor Name</th>
<th>Country</th>
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<tbody>
<tr>
<td>1</td>
<td>Bray Control India Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>2</td>
<td>EL-O-Matic India Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>3</td>
<td>Rotex Manufacturers &amp; Engineers Pvt Ltd</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>Schrader Duncan Ltd.</td>
<td>India</td>
</tr>
</tbody>
</table>

**Self actuated pressure control valve**

<table>
<thead>
<tr>
<th>No.</th>
<th>Vendor Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fisher Controls</td>
<td>India</td>
</tr>
<tr>
<td>2</td>
<td>Nirmal Industrial controls private limited</td>
<td>India</td>
</tr>
<tr>
<td>3</td>
<td>Nu tech Controls (upto 10&quot;, 600#)</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>Pneucon Valves Pvt. Ltd. (upto 4&quot;, 150#)</td>
<td>India</td>
</tr>
<tr>
<td>5</td>
<td>Samsons Controls Pvt. Ltd. (upto 2&quot;, 150#)</td>
<td>India</td>
</tr>
</tbody>
</table>

**Electropneumatic Positioner**

<table>
<thead>
<tr>
<th>No.</th>
<th>Vendor Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fisher Controls</td>
<td>India</td>
</tr>
<tr>
<td>2</td>
<td>Siemens Ltd.</td>
<td>India</td>
</tr>
</tbody>
</table>

**Desuperheaters**

<table>
<thead>
<tr>
<th>No.</th>
<th>Vendor Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Circor Flow Technologies India Pvt. Ltd</td>
<td>India</td>
</tr>
<tr>
<td>2</td>
<td>Chemtrols</td>
<td>India</td>
</tr>
<tr>
<td>3</td>
<td>CCI</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>EMET Controls Pvt. Ltd. (Desuperheating Control Valves 1-1/2&quot;, 600# * 3&quot;, 2500#)</td>
<td>India</td>
</tr>
</tbody>
</table>
# Vendor List

## Pressure Reducing Station

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Circor Flow Technologies India Pvt. Ltd (1&quot; to 20&quot;, up to 150#, 1&quot; to 10&quot;, up to 1500#, 1&quot; to 8&quot; up to 2500#)</td>
</tr>
</tbody>
</table>

## Pressure Regulator

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Chemtrol Industries Ltd.</td>
</tr>
</tbody>
</table>

## Safety Valves & Thermal Relief Valves Upto 2500#

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>AST S.P.A</td>
</tr>
<tr>
<td>2.</td>
<td>Bliss anand private limited (8&quot; * 10&quot;, 300#, 6&quot; * 8&quot; 600#, 4&quot; * 6&quot; 1500#)</td>
</tr>
<tr>
<td>3.</td>
<td>FaingerLeser Valves (P) Ltd. (Upto 600#, ½&quot; To 6&quot;)</td>
</tr>
<tr>
<td>4.</td>
<td>Instrumentation Ltd. (Palakkad)</td>
</tr>
<tr>
<td>5.</td>
<td>Keystone</td>
</tr>
<tr>
<td>6.</td>
<td>Pentair Sanmar Ltd.</td>
</tr>
<tr>
<td>7.</td>
<td>Nu tech controls (upto 2&quot;, 300# * 3&quot;, 150#)</td>
</tr>
<tr>
<td>8.</td>
<td>Valve Tech Industries</td>
</tr>
<tr>
<td>9.</td>
<td>Weir Bdk Valves</td>
</tr>
<tr>
<td>10.</td>
<td>BOPP &amp; Reuther Messtechnic GMBH</td>
</tr>
<tr>
<td>12.</td>
<td>Dresser Industries Incorporated</td>
</tr>
<tr>
<td>13.</td>
<td>Dresser Valve &amp; Controls</td>
</tr>
<tr>
<td>14.</td>
<td>Farris</td>
</tr>
<tr>
<td>15.</td>
<td>Itochu Corporation</td>
</tr>
<tr>
<td>16.</td>
<td>Parcol Spa (For Urea Service Also)</td>
</tr>
<tr>
<td>17.</td>
<td>Sapag GEC Alsthom</td>
</tr>
<tr>
<td>18.</td>
<td>Tai Milano S.P.A</td>
</tr>
<tr>
<td>19.</td>
<td>Teledyne Fluid Systems</td>
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</table>

## Vacuum Breakers

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Country</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fainger Engineering</td>
</tr>
<tr>
<td>2.</td>
<td>Potego India Pvt. Ltd.</td>
</tr>
<tr>
<td>3.</td>
<td>Braunschweiger Flammenfilter</td>
</tr>
<tr>
<td>4.</td>
<td>Itochu Corporation</td>
</tr>
<tr>
<td>5.</td>
<td>Parcol Spa</td>
</tr>
<tr>
<td>7.</td>
<td>Tai Milano S.P.A</td>
</tr>
<tr>
<td>8.</td>
<td>Whessoe Varec Limited</td>
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</table>

## Rupture Discs

<table>
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<tr>
<th>Vendor</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Bs&amp;B Safety Systems (India) Limited</td>
</tr>
<tr>
<td>2.</td>
<td>Fainger Engineering</td>
</tr>
<tr>
<td>3.</td>
<td>Tyco Sanmar</td>
</tr>
<tr>
<td>4.</td>
<td>Continental Controls Inc.</td>
</tr>
<tr>
<td>5.</td>
<td>Fike Europe</td>
</tr>
<tr>
<td>6.</td>
<td>Sapag GEC Alsthom</td>
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<tr>
<td>7.</td>
<td>Teledyne Fluid Systems</td>
</tr>
</tbody>
</table>

## Pilot relief valves

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>AST S.P.A (inlet size upto 3&quot;, up to 1500#, outlet size up to 4&quot;, up to 300#, inlet size up to 4&quot;, up to 300#, inlet size up to 6&quot;, up to 150#, outlet size up to 8&quot;, up to 150#)</td>
</tr>
<tr>
<td>2.</td>
<td>Bliss Anand Private Limited (Size 1&quot;* 2&quot; 2500#)</td>
</tr>
</tbody>
</table>

## Low pressure relief valve

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Protego India Pvt. Ltd. (less than 1 BAR with flame arrester)</td>
</tr>
</tbody>
</table>
### Flame Arrestor

<table>
<thead>
<tr>
<th>No.</th>
<th>Company</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Protego India Pvt. Ltd</td>
<td>India</td>
</tr>
</tbody>
</table>

### Control Panel

<table>
<thead>
<tr>
<th>No.</th>
<th>Company</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Electronics corporation of india ltd.</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>Ex protecta</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>Hulasi metals pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>4.</td>
<td>Industrial control appliances (p) ltd.</td>
<td>India</td>
</tr>
<tr>
<td>5.</td>
<td>Jaisun &amp; hutchisun control ltd.</td>
<td>India</td>
</tr>
<tr>
<td>6.</td>
<td>Prima automation (india) pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>7.</td>
<td>Pyrotech electronics pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>8.</td>
<td>Tan swa technologies INC</td>
<td>India</td>
</tr>
<tr>
<td>9.</td>
<td>United electric co (delhi ) pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>10.</td>
<td>Yokogawa india limited</td>
<td>India</td>
</tr>
<tr>
<td>11.</td>
<td>Instromet international N.V.</td>
<td>Holland</td>
</tr>
</tbody>
</table>

### Programmable Logic Controller- Package

<table>
<thead>
<tr>
<th>No.</th>
<th>Company</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ABB India Limited</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>Emerson Process Management (I) Pvt. Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>Ge Fanuc Systems Prvivate Limited</td>
<td>India</td>
</tr>
<tr>
<td>4.</td>
<td>Honeywell Automation India Limited</td>
<td>India</td>
</tr>
<tr>
<td>5.</td>
<td>Rockwell Automation India Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>6.</td>
<td>Siemens Ltd.,</td>
<td>India</td>
</tr>
<tr>
<td>7.</td>
<td>Yokogawa</td>
<td>India</td>
</tr>
<tr>
<td>8.</td>
<td>GE fanuc automation north America INC (fault tolerant TMR)</td>
<td>U.S.A</td>
</tr>
<tr>
<td>9.</td>
<td>Hima paul Hildebrandt GmbH +Co KG (fail safe )</td>
<td>Germany</td>
</tr>
<tr>
<td>10.</td>
<td>Marconi italiana (non fail safe )</td>
<td>Italy</td>
</tr>
<tr>
<td>11.</td>
<td>Omron corporation (Relay)</td>
<td>Japan</td>
</tr>
<tr>
<td>12.</td>
<td>RTP Control system</td>
<td>U.S.A /India</td>
</tr>
<tr>
<td>13.</td>
<td>Triconex (fault tolerant TMR)</td>
<td>Singapore</td>
</tr>
<tr>
<td>14.</td>
<td>Triconex (Schenider)</td>
<td>Singapore</td>
</tr>
</tbody>
</table>

### Distributed Control System

<table>
<thead>
<tr>
<th>No.</th>
<th>Company</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ABB India Limited</td>
<td>India</td>
</tr>
<tr>
<td>2.</td>
<td>Emerson process management India Pvt. ltd.</td>
<td>India</td>
</tr>
<tr>
<td>3.</td>
<td>Foxboro</td>
<td>India/Intl.</td>
</tr>
<tr>
<td>4.</td>
<td>Honeywell Automation India Limited</td>
<td>India</td>
</tr>
<tr>
<td>5.</td>
<td>Siemens Ltd.</td>
<td>India</td>
</tr>
<tr>
<td>6.</td>
<td>Yokogawa Limited</td>
<td>India</td>
</tr>
<tr>
<td>7.</td>
<td>Bailey controls company</td>
<td>U.S.A</td>
</tr>
<tr>
<td>8.</td>
<td>Emerson process management Singapore ltd.</td>
<td>Singapore</td>
</tr>
<tr>
<td>9.</td>
<td>Honeywell Inc.</td>
<td>U.S.A</td>
</tr>
<tr>
<td>10.</td>
<td>Invensys</td>
<td>Holland</td>
</tr>
<tr>
<td>11.</td>
<td>Siemens AG</td>
<td>Germany</td>
</tr>
<tr>
<td>12.</td>
<td>Yokogawa Electric Corporation</td>
<td>Japan</td>
</tr>
</tbody>
</table>

### ESD SHUT-DOWN SYSTEM

<table>
<thead>
<tr>
<th>No.</th>
<th>Company</th>
<th>Country</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>HONEYWELL</td>
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<tr>
<td>2.</td>
<td>HIMA CONTROLS</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>PAUL HILDEBRANDT (HIMA)</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>RTP Control system</td>
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</tr>
<tr>
<td>5.</td>
<td>Rockwell automation pvt. Ltd.</td>
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</tr>
<tr>
<td>6.</td>
<td>SIEMENS AG</td>
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</tr>
<tr>
<td>7.</td>
<td>TRICONEX / IMPROTEC</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>YOKOGAWA</td>
<td></td>
</tr>
<tr>
<td>Multiplexer / Remote I/O</td>
<td>India</td>
<td>U.K.</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>1. Mtl Instrument Limited</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Pepperl + Fuch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. M.system Co. Ltd. (Remote I/O; Model No.R3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. M.T.L., U.K.</td>
<td></td>
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</tr>
<tr>
<td>5. Pepperl + Fuchs Pte Ltd.</td>
<td></td>
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<tr>
<td>6. Stahl-Und Apparatebau Hans LefferGmbH</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Receiver Instruments (Indicator, Controller, Recorder)</th>
<th>India</th>
<th>U.A.</th>
<th>Japan</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ABB India Limited</td>
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</tr>
<tr>
<td>2. Chino-Laxsons (India) Limited (Only Recorder)</td>
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<tr>
<td>3. Eurotherm Del India Limited</td>
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</tr>
<tr>
<td>4. Honeywell Automation India Limited</td>
<td></td>
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</tr>
<tr>
<td>5. Masibus Automation &amp; Instrumentation Pvt.Ltd. (Receiver Instruments except recorder)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Moore Controls Ltd.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>7. Yokogawa Limited</td>
<td></td>
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</tr>
<tr>
<td>8. ChinoCorpn.</td>
<td></td>
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<tr>
<td>9. Heraeus Electro-Nite International N.V.</td>
<td></td>
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</tr>
<tr>
<td>10. Honeywell Inc.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>11. Siemens Ag, Germany</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Yokogawa Electric Corporation</td>
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</table>

<table>
<thead>
<tr>
<th>Alarm Annunciator</th>
<th>India</th>
<th>U.K.</th>
<th>U.A.</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Industrial Instruments &amp; Controls</td>
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<tr>
<td>2. Shree Electronics</td>
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</tr>
<tr>
<td>3. M.T.L., U.K.</td>
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<td>5. Rileyan Panalarm</td>
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<table>
<thead>
<tr>
<th>Temperature Scanner</th>
<th>India</th>
<th>U.K.</th>
<th>U.A.</th>
<th>Japan</th>
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</thead>
<tbody>
<tr>
<td>1. Industrial Instrumentation</td>
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</tr>
<tr>
<td>2. Protocontrol Instruments (I) Pvt. Ltd.</td>
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</table>

<table>
<thead>
<tr>
<th>Cctv / Access System</th>
<th>India</th>
<th>U.K.</th>
<th>U.A.</th>
<th>Japan</th>
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</thead>
<tbody>
<tr>
<td>1. Honeywell Automation India Limited</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Yokogawa Limited</td>
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<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Miscellaneous Items (Rtu / ScadaEtc)</th>
<th>India</th>
<th>U.K.</th>
<th>U.A.</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ABB India Limited</td>
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<tr>
<td>2. Rockwell Automation India Pvt. Ltd.</td>
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<tr>
<td>3. Siemens Ltd. (Simatic WINcc)</td>
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<table>
<thead>
<tr>
<th>Energy meter</th>
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<th>U.K.</th>
<th>U.A.</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. M.system co. Ltd.( Model No. 53U)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Surge Protection Devices</th>
<th>India</th>
<th>U.A.</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Phoenix Contact (India) Pvt. Ltd.</td>
<td></td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Wiring Ducts</th>
<th>India</th>
<th>U.A.</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Trinity touch Pvt.Ltd.</td>
<td></td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>DIN Rail</th>
<th>India</th>
<th>U.A.</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Trinity touch Pvt.Ltd.</td>
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<td></td>
<td></td>
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<table>
<thead>
<tr>
<th>Interface Module</th>
<th>India</th>
<th>U.A.</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Trinity touch Pvt.Ltd.</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Cable connector</th>
<th>India</th>
<th>U.A.</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Phoenix contact (India) Pvt. Ltd.</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Advance Process Control System</th>
<th>India</th>
<th>U.A.</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Vendor</td>
<td>Country</td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>----------------------------------------------------</td>
<td>-----------------</td>
<td></td>
</tr>
<tr>
<td><strong>Speed Indicator</strong></td>
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<td></td>
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</tr>
<tr>
<td>1.</td>
<td>Yokogawa India Limited</td>
<td>India</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Bentley NevedaLlc</td>
<td>U.S.A</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Jacquet</td>
<td>Switzerland</td>
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</tr>
<tr>
<td>4.</td>
<td>Pepperl + Fuch</td>
<td>Germany</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Pepperl + Fuchs Pte Ltd.</td>
<td>Singapore</td>
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<td>6.</td>
<td>Shinkawa Electric Co.</td>
<td>Japan</td>
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<td><strong>Burner Management System</strong></td>
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<td>1.</td>
<td>Siemens (TMR/QMR)</td>
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<td>Triconex (TMR/QMR)</td>
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<td>Honeywell (TMR/QMR)</td>
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<td>4.</td>
<td>Yokogawa (TMR/QMR)</td>
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<td>5.</td>
<td>Rockwell Automation Pvt. Ltd.</td>
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<td><strong>Instrument Power &amp; Control Cables</strong></td>
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<tr>
<td>1.</td>
<td>Associated Cables Ltd.</td>
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<td>2.</td>
<td>Associated Flexibles &amp; Wires Pvt. Ltd.</td>
<td>India</td>
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<td>3.</td>
<td>Cords Cable Industries Ltd.</td>
<td>India</td>
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<td>4.</td>
<td>Delton Cables Ltd</td>
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<td>5.</td>
<td>Insucon Cables &amp; Conductors (P) Ltd. (For Smaller Non-Critical Projects)</td>
<td>India</td>
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<td>6.</td>
<td>J K Cables Limited</td>
<td>India</td>
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<td>7.</td>
<td>Kei Industries Limited</td>
<td>India</td>
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<td>8.</td>
<td>Leoni cable solutions</td>
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<td>9.</td>
<td>Paramount Cable Corporation</td>
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<td>10.</td>
<td>T C Communications Pvt Ltd</td>
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<td>11.</td>
<td>Thermo Cables Limited</td>
<td>India</td>
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<td>12.</td>
<td>Toshniwal Cables</td>
<td>India</td>
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<td>13.</td>
<td>Udey Pyro Cables Pvt Ltd</td>
<td>India</td>
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<tr>
<td><strong>Extension &amp; Compensating Cables</strong></td>
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<td>1.</td>
<td>Associated Cables Ltd.</td>
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<td>Associated Flexibles &amp; Wires Pvt. Ltd.</td>
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<td>3.</td>
<td>Cords Cable Industries Ltd.</td>
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<td>4.</td>
<td>Delton Cables Ltd</td>
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<td>5.</td>
<td>General Instruments Consortium,</td>
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<td>6.</td>
<td>J K Cables Limited</td>
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<td>7.</td>
<td>Kei Industries Limited</td>
<td>India</td>
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<td>8.</td>
<td>Paramount Cable Corporation</td>
<td>India</td>
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<td>9.</td>
<td>Thermopads Pvt. Ltd.</td>
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<td>10.</td>
<td>Toshniwal Cables</td>
<td>India</td>
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<td><strong>Cable Trays &amp; Accessories (Al./Gi)</strong></td>
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<td>1.</td>
<td>D-Y Engineers</td>
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<td>2.</td>
<td>Globe Electrical Industries</td>
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<td>3.</td>
<td>HOPPES</td>
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<td>4.</td>
<td>Indiana Engg Works Pvt Ltd</td>
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<td>5.</td>
<td>Metalite Industries</td>
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<td>6.</td>
<td>Parekh Engineering Company</td>
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<td>Sadhana Engineering Corporation</td>
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<td>8.</td>
<td>Steelite Engineering Limited</td>
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<td><strong>Multi Transit Inlet System</strong></td>
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<td>1.</td>
<td>Hawke International</td>
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<td>MctBrattbergAktiebolag</td>
<td>Sweden</td>
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<td>3.</td>
<td>RoxtecAb</td>
<td>Sweden</td>
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<td>1.</td>
<td>Baliga Lighting Equipments Limited</td>
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<td>2.</td>
<td>Ceag Flameproof Control Gears Pvt.Ltd.</td>
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<td>3.</td>
<td>Ex-protecta</td>
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<td>Flameproof Equipments Pvt. Ltd.</td>
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<td>5.</td>
<td>Flexpro Electicals Pvt. Ltd.</td>
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<td>6.</td>
<td>TAN SWA technologies Inc (Junction Box)</td>
<td>India</td>
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<tr>
<td>7.</td>
<td>Trinity Touch Pvt. Ltd. (Only cable Glands upto size 25M)</td>
<td>India</td>
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<td>8.</td>
<td>Stahl-Und Apparatebau Hans Leffer GmbH</td>
<td>Germany</td>
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</tbody>
</table>

**Junction Box & Cable Gland**

**CS Seamless Pipes – As per Piping list**

| 1. | Indian tube Co.(Tata Div of tubes & pipes) | India |
| 2. | ISMT limited | India |
| 3. | Maharasthra seamless limited | India |
| 4. | Dalmine SPA | Italy |
| 5. | ETS Trouvay & Cauvin | France |
| 6. | Horst kurvers GmbH | Germany |
| 7. | Hyundai Corporation | Korea |
| 8. | IBF seamless pipes SPA | Italy |
| 9. | Mannesmann Hnael AG | Germany |
| 10. | Marubeni Itochu Steel | Japan |
| 11. | Nippon steel corporation | Japan |
| 12. | Nissho IWAI Corporation | Japan |
| 13. | Okura & Co. Ltd. | Japan |
| 14. | Sojitz Corporation | Japan |
| 15. | Sumitomo metal industries Ltd. | Japan |
| 16. | Phoceenne | France |
| 17. | Vomal International Limited | UK |

**SS Seamless Pipes – As per piping list**

| 1. | Choksi tube company limited | India |
| 2. | Maxim tubes company pvt. Ltd. | India |
| 3. | Nuclear fuel complex | India |
| 4. | Ratnamani metals & tubes limited | India |
| 5. | Remi edelstahl tubular ltd. | India |
| 6. | Dalmine SPA | Italy |
| 7. | Phoceenne | France |
| 8. | TPS technitube Rohrenwerke | Germany |
| 9. | T.T.I tubecex tubos inoxidables S.A. (1/2" NB SS pipe) | Spain |

**SS Tubes**

| 1. | Choksi Tube Company Ltd. | India |
| 2. | Matim Tubes Company Pvt. Ltd. | India |
| 3. | Nuclear Fuel Complex | India |
| 4. | Ratnamani Metals & Tubes Limited | India |
| 5. | Sandvik | India |
| 6. | Itochu Corporation (Rep.KubotaCorpn.) | Japan |
| 7. | Nishitani & Co. Ltd. | Japan |
| 8. | Sumitomo Metal Industries Ltd. | Japan |

**Pipe Fittings**

<p>| 1. | Eby industries | India |
| 2. | Excel hydropneumatics pvt. Ltd. | India |
| 3. | Micro precision products pvt. Ltd. | India |
| 4. | Precision engineering industries | India |</p>
<table>
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<tr>
<th>No.</th>
<th>Vendor Name</th>
<th>Location</th>
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<tr>
<td>5</td>
<td>Tecnomatic (India) pvt. Ltd.</td>
<td>India</td>
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<td>6</td>
<td>Wesmec engineering pvt. Ltd.</td>
<td>India</td>
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<tr>
<td>7</td>
<td>Celleir</td>
<td>France</td>
</tr>
<tr>
<td>8</td>
<td>Cesare bonetti SPA</td>
<td>Italy</td>
</tr>
<tr>
<td>9</td>
<td>Dewrance &amp; Co. Ltd.</td>
<td>U.K.</td>
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<tr>
<td>10</td>
<td>Hopkinsons Ltd.</td>
<td>U.K.</td>
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<tr>
<td>11</td>
<td>Siemens AG PGI</td>
<td>Germany</td>
</tr>
<tr>
<td>12</td>
<td>Sumitomo metal industries ltd.</td>
<td>Japan</td>
</tr>
<tr>
<td>13</td>
<td>Thyssen krupp stahlunion Gmbh</td>
<td>Germany</td>
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<tr>
<td>14</td>
<td>Tecnomatic SPA</td>
<td>Italy</td>
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**Instrument Miniature Valves**

1. Audco India Limited (L&T Valves Divn.) India
2. Aura Inc India
3. Bhel (valves division) India
4. Chemtrol Industries Ltd India
5. Chemtrols Samil (India) Pvt Ltd India
6. Comfit & Valves Pvt. Ltd. India
7. Excel Hydro-Pneumatics Pvt Ltd, India
8. Excelsior Engg Works India
9. Hyd- Air Engineering works Lonavla India
10. Ksb Pumps Limited (Valves Divn) India
11. Panam Engineers India
12. Tecnomatic (India) Pvt. Ltd. India
14. BFE boneey forge valve License Italy
15. Celleir S.A. France
16. Crane Company International Sales U.S.A
17. Dewrance & Co. Ltd. U.K.
18. Euromisure Cremona Italy
19. Hopkinsons Ltd. U.K.
20. Kosei Sanyog Ltd. Japan
21. Swagelok company/creximco U.S.A
22. Sumitomo metal industries ltd. Japan
23. Technomatic SPA Italy
24. Velan engineering Co. Limited U.K.
25. Wesmec engineering pvt. Ltd India

**Purge rotameter**

1. Eureka industrial equipments Pvt. Ltd. India
2. Instrumentation engineers pvt. Ltd. India
3. Placka instruments & engineers pvt. ltd India

**AIR HEADER/ADPOT**

1. Wesmec engineering pvt. Ltd. India

**Condensate pot**

1. HYDROPEUMATICS India
2. MICRO-PRECISION PRODUCTS India
3. TECHNOMATIC (I) P. LTD. India
4. Wesmec engineering pvt. Ltd. India

**Valve manifolds**

1. Comfit & Valves Pvt. Ltd. India
2. EXCEL HYDROPEUMATICS PVT. LTD. India
3. HYDER India
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<th>Vendor Name</th>
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<td>INSTRUMENTATION LTD.</td>
<td>India</td>
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<td>5</td>
<td>MICRO PRECISION</td>
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<tr>
<td>6</td>
<td>NORDIVAL (SWAGELOC)</td>
<td>India</td>
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<td>7</td>
<td>PARKER</td>
<td>India</td>
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<td>8</td>
<td>TECHNOMATIC</td>
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<tr>
<td>9</td>
<td>Wesmec engineering pvt. Ltd.</td>
<td>India</td>
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**Calibration equipment & services**

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<th>Vendor Name</th>
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<td>1</td>
<td>Tempsens instruments (i) pvt. Ltd.</td>
<td>India</td>
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<tr>
<td>2</td>
<td>Fluke</td>
<td>Singapore</td>
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<td>3</td>
<td>Omega Engineering</td>
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**Enclosures**

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<th>Vendor Name</th>
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<tr>
<td>1</td>
<td>Trinity touch pvt. Ltd. (weatherproof size 80 * 80 mm)</td>
<td>India</td>
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**Instrument contractor for inst. Construction /erection works**

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<th>Vendor Name</th>
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<tr>
<td>1</td>
<td>Blue star</td>
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<td>2</td>
<td>Bells control ltd.</td>
<td>India</td>
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<tr>
<td>3</td>
<td>Godrej &amp; Boyce mfg. co. ltd</td>
<td>India</td>
</tr>
<tr>
<td>4</td>
<td>ICB Contractor Pvt. Ltd.</td>
<td>India</td>
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<tr>
<td>5</td>
<td>Jasubhai Industries</td>
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<td>6</td>
<td>Koso india pvt. Ltd. (kent introl control valve divn.)</td>
<td>India</td>
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<td>7</td>
<td>L&amp;T (construction contracts Divn.)</td>
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<td>8</td>
<td>Miraj instrumentation service (upto 0.5 crores)</td>
<td>India</td>
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<tr>
<td>9</td>
<td>Narayan engineering (&lt; Rs. 5 lacs (small project))</td>
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<td>10</td>
<td>Pace process control pvt. Ltd.</td>
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<td>11</td>
<td>Peron engg. Construction ltd.</td>
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<td>12</td>
<td>Protect control pvt. Ltd.</td>
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<tr>
<td>13</td>
<td>Technimont ICB ltd.</td>
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### 8.0 MECHANICAL – PIPING

#### CS WELDED PIPES TO API 5L SPIRAL LONG. WELDED

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<th>Sl.No</th>
<th>Vendor’s Name</th>
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<tr>
<td>1</td>
<td>HEAVY METAL PIPE CENTRE (UPTO 24&quot; (UPTO SCHXXS))</td>
<td>INDIA</td>
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<td>2</td>
<td>JINDAL PIPES LTD. (2” TO 14”)</td>
<td>INDIA</td>
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<td>3</td>
<td>JOTINDRA STEEL &amp; TUBES LTD. (½” TO 14”)</td>
<td>INDIA</td>
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<tr>
<td>4</td>
<td>KALPESH TUBE(INDIA), (TRADER)</td>
<td>INDIA</td>
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<td>5</td>
<td>LALIT PIPES &amp; PIPES LTD.. (16&quot; to 64&quot; thickness upto 20mm)</td>
<td>INDIA</td>
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<td>6</td>
<td>MUKAT PIPES LTD.</td>
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<td>7</td>
<td>P.K.FORGE &amp; FITTING INDUSTRIES</td>
<td>INDIA</td>
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<td>8</td>
<td>PRATIBHA INDUSTRIES LTD. (16&quot; to 24&quot; thickness 6mm to 14.27mm)</td>
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<td>RATNAMANI METALS &amp; TUBES LTD.</td>
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<td>SAGAR STEEL CORPORATION (TRADER)</td>
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<td>11</td>
<td>SAIL</td>
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<td>SURINDRA ENGINEERING CO. PVT. LTD.</td>
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<td>13</td>
<td>SURYA ROSHINI LTD (GR. A 3” TO 4”, GR. B, 6” TO 14”)</td>
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<td>14</td>
<td>THE BENGAL MILL STORES SUPPLY CO.(TRADER)</td>
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<td>15</td>
<td>WELSPUN GUJARAT STAHL ROHREN LIMITED (FOR ANJAR AND DAHEJ PLANTS) (UPTO 72” 50 MM THK FOR DAHEJ PLANT AND UPTO 100” 30 MM THK. FOR ANJAR PLANT.)</td>
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<td>PHOCEENNE</td>
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<td>ETS TROUVAY &amp; CAUVIN</td>
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<td>RACCORTUBI SRL</td>
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<td>KOSEI SANGYO LTD</td>
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<td>MITSUBISHI CORPORATION</td>
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<td>26</td>
<td>NIPPON STEEL CORPORATION</td>
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<td>NISHITANI &amp; CO. LTD.</td>
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<td>NISSHO IWAI CORPORATION</td>
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<td>OKURA &amp; CO. LTD.</td>
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<td>SOJITZ CORPORATION</td>
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<td>SUMITOMO METAL INDUSTRIES LTD.</td>
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<td>HYUNDAI CORPORATION</td>
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<td>33</td>
<td>BRITISH STEEL CORPORATION</td>
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<td>34</td>
<td>CORUS TUBES LIMITED</td>
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<td>35</td>
<td>SAW PIPES USA, INC</td>
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**CS/AS LTCS SEAMLESS PIPES**

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<td>CHETAN STEELS (Upto 12&quot;, SCH80)</td>
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<td>3</td>
<td>HEAVY METAL &amp; TUBES (Upto 8&quot;, thickness upto 18.26mm)</td>
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<td>4</td>
<td>HEAVY METAL PIPE CENTRE (UPTO 24&quot; (UPTO SCHXXS)</td>
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<td>5</td>
<td>INDIAN TUBE CO. (TATA DEV. OF TUBES &amp;PIPES)</td>
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<td>6</td>
<td>ISMT LIMITED</td>
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<td>JAY LAKSHMI STEEL &amp; ENGG. CO.</td>
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<td>JINDAL SAW LTD.</td>
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<td>JAY LAKSHMI STEEL &amp; ENGG. CO.</td>
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<td>T.T.I. – TUBACEX TUBOS INOXIDABLES, S.A.</td>
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<td>SOSTA BV (UPTO 72&quot; (THICKNESS UPTO 25.4 MM))</td>
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**SS SEAMLESS TUBES**

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<td>T.T.I.-TUBACEX TUBOS INOXIDABLES, S.A.(OD 15.8 MM TO 250.0 MM, WALL THK.1.0 MM)</td>
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### FITTINGS: CS/AS/SS SEAMLESS & FORGED

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<td>CSA FITTINGS (Forged ½” to 2”-upto 900#, Seamless: 2” to 8”- upto SCHXXS)</td>
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<td>PETROCHEM INDUSTRIES (Seamless: Upto 16&quot; (All Fittings) &amp; upto 36&quot; (caps) SCH : XXS /80S, Forged: upto 3&quot;-6000#)</td>
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<td>SUMITOMO METAL INDUSTRIES LTD.</td>
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<td>HAITIMA CORPORATION</td>
<td>TAIWAN</td>
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<td>CORUS TUBES LIMITED</td>
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<td>BRITISH STEEL CORPORATION</td>
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<td>EUROTUBE LIMITED</td>
<td>U.K.</td>
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<tr>
<td>VOMAL INTERNATIONAL LIMITED</td>
<td>U.K.</td>
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<tr>
<td>BONNEY FORGE</td>
<td>U.S.A.</td>
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**FORGED FLANGES**

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<thead>
<tr>
<th>Vendor Name</th>
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<tbody>
<tr>
<td>AJAY FORGING PVT. LTD</td>
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<td>AMFORGE INDUSTRIES</td>
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<td>ANANDMAYEE FORGINGS PVT. LTD.</td>
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<tr>
<td>C D ENGINEERING</td>
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<tr>
<td>CHAUDHARY HAMMER WORKS (P) LTD.</td>
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<tr>
<td>CHETAN STEELS (UPTO 6&quot;, 150#)</td>
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<tr>
<td>ECHJAY INDUSTRIES LTD</td>
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<tr>
<td>FERROUS ALLOYS FORGING PVT. LTD</td>
<td>INDIA</td>
</tr>
<tr>
<td>GOOD LUCK ENGINEERING CO. (½”-12&quot; (UPTO 2500#), 14&quot;-16&quot; (UPTO 900#), 18&quot;-32&quot; (UPTO 600#), 34&quot;-48&quot; (UPTO 300#)),</td>
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<tr>
<td>J.K FORGINGS</td>
<td>INDIA</td>
</tr>
<tr>
<td>KUNJ FORGINGS PVT. LTD, (MATERIAL CS/SS/AS) (upto 60&quot; (upto 300#) &amp; upto 12&quot; (upto 2500#))</td>
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<tr>
<td>MAHESH INDUSTRIES (Upto 8&quot; -150#, material ASTM A105 only)</td>
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<tr>
<td>P.K TUBES &amp; FITTINGS PVT. LTD. (Upto 24&quot;(upto1500#) &amp; Upto 12&quot;(upto2500#) Spectacle Blind and Spacer &amp; Blinds only)</td>
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<tr>
<td>PARAMOUNT FORGE (CS,AS &amp; SS : ½” TO 42&quot; (UPTO 600#), ½” TO 24&quot; (UPTO 900#), ½ “ TO 16&quot; ( UPTO 1500#), ½&quot; TO 12&quot; (UPTO 2500#)).</td>
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<tr>
<td>PERFECT MARKETING (P) LTD.</td>
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<td>PUNJAB STEEL</td>
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<tr>
<td>R D FORGE (A UNIT OF R D CHEMICALS PVT LTD) (Upto 54&quot; (150#), 42&quot; (upto 600#), 20&quot; (upto 1500#) &amp; 12&quot; (2500#))</td>
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<td>RAJENDRA FORGE INDUSTRIES (CS &amp; SS : UPTO 12&quot;, 300#)</td>
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<td>S &amp; G ENGINEERS (P) LTD.</td>
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<td>SANGHVI FORGINGS &amp; ENGINEERING LTD</td>
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<td>SANGHVI METALS (TRADER)</td>
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<td>SAWAN ENGINEERS</td>
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<td>TECHNO FORGE LTD. (UPTO 42&quot; (UPTO 300#), UPTO 24&quot; (600#), UPTO 20&quot; (900#), UPTO 16&quot; (1500#),</td>
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<td>Vendor Name</td>
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<td>24</td>
<td>TUBE BEND (CALCUTTA) PVT LTD</td>
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<td>PHOCEENNE</td>
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<td>26</td>
<td>ETS TROUVAY &amp; CAUVIN</td>
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<td>27</td>
<td>HORST KURVERS GMBH</td>
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<td>28</td>
<td>I.S. INTERNATIONAL</td>
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<td>29</td>
<td>MANTOVANI SPA</td>
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<td>30</td>
<td>OFFICINE NICOLA GALPERTI &amp; FIGLIO S.P.A</td>
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<td>31</td>
<td>RACCORTUBI SRL</td>
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<td>32</td>
<td>NICHINAN SANGYO CO. LTD.,</td>
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<tr>
<td>33</td>
<td>NISHTANI &amp; CO. LTD.</td>
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<tr>
<td>34</td>
<td>SOJITZ CORPORATION</td>
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<tr>
<td>35</td>
<td>VOMAL INTERNATIONAL LIMITED</td>
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</table>

**GATE/ GLOBE/ CHECK VALVES CS/SS/AS < 900 LBS**

<table>
<thead>
<tr>
<th></th>
<th>Vendor Name</th>
<th>Country</th>
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<tbody>
<tr>
<td>1</td>
<td>AV VALVES LTD. (CAST UPTO 42&quot;,150#) 28&quot; 300#, 24&quot; (600#) &amp; FORGE UPTO 2&quot; (800#)</td>
<td>INDIA</td>
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<td>2</td>
<td>ADVANCE VALVES (2&quot;-80&quot; (Upto 600#) Dual Plate Check Valves only)</td>
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<td>3</td>
<td>ASSOCIATED TOOLINGS (I) PVT. LTD.</td>
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<tr>
<td>4</td>
<td>AUDCO INDIA LIMITED (L&amp;T VALVES DIVN.)</td>
<td>INDIA</td>
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<tr>
<td>5</td>
<td>AUTOCAP INDUSTRIES (1/2&quot; to 2&quot; 800# (only CS &amp; SS)</td>
<td>INDIA</td>
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<tr>
<td>6</td>
<td>BELL- O-SEAL VALVES LTD.( FOR ZERO LEAKAGE, HAZARDOUS FLUIDS.)</td>
<td>INDIA</td>
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<tr>
<td>7</td>
<td>BHEL (VALVES DIVISION)</td>
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<tr>
<td>8</td>
<td>BRIGHTECH VALVES AND CONTROLS PVT. LTD. (Upto 8&quot; x 300#)</td>
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<td>9</td>
<td>CHEMTECH INDUSTRIAL VALVES PVT. LTD.</td>
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<td>10</td>
<td>CRAWLEY &amp; RAY (FOUNDERS &amp; ENGINEERS) PVT. LTD. (&lt;=300#, (only CS))</td>
<td>INDIA</td>
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<tr>
<td>11</td>
<td>DATRE CORPORATION LTD. (Upto 300#, 2&quot; to 8&quot; (Gate), 2&quot; to 6&quot; (Globe &amp; Check Valves))</td>
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<tr>
<td>12</td>
<td>DEWRANCE MACNEILL &amp; CO. LTD.</td>
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<td>13</td>
<td>ECONO VALVES PVT. LTD.</td>
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<td>14</td>
<td>EXPERT ENGINEERING ENTERPRISES</td>
<td>INDIA</td>
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<tr>
<td>15</td>
<td>FLOCON SYSTEMS PVT. LTD. (CS upto 6&quot; – 1500#)</td>
<td>INDIA</td>
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<tr>
<td>16</td>
<td>FLOVEL VALVES PVT. LTD. (SINGLE DISC, DULA PLATE &amp; NOZZLE CHECK VALVES ONLY : UPTO 48&quot; (150#) &amp; 24 (UPTO 600#)</td>
<td>INDIA</td>
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<tr>
<td>17</td>
<td>FLUIDTECH EQUIPMENT PVT. LTD. (CAST # CS &amp; SS 2&quot; TO 12&quot; 150# &amp; 2&quot; TO 8&quot; 300 # AND FORGED (CS AND SS) ½&quot; TO 2&quot; (800#)</td>
<td>INDIA</td>
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<td>18</td>
<td>FORWARD ALLOYS &amp; CASTINGS (UPTO 14&quot;)</td>
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<td>19</td>
<td>GURU INDUSTRIAL VALVES PVT. LTD.</td>
<td>(Cast CS only: upto 24&quot; (150#), 20&quot; (300#), 10&quot; (600#) &amp; Forged: upto 2&quot; (800#))</td>
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<td>20</td>
<td>HAWA ENGINEERS LTD.</td>
<td>(Gate Valves: upto 40&quot; (150#), upto 26&quot; (300#), upto 24&quot; (600#), upto 2&quot; (800#); Globe Valves: upto 20&quot; (150#), upto 16&quot; (300#), upto 12&quot; (600#), upto 2&quot; (800#), Check Valves: upto 36&quot; (150#), upto 24&quot; (300#), upto 16&quot; (600#), upto 2&quot; (800#) (Dual Plate: 36&quot; (150#))</td>
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<td>21</td>
<td>HAWA VALVES INDIA PVT. LTD.</td>
<td>(CS upto 6&quot;, 150#)</td>
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<td>22</td>
<td>HI-TECH VALVES PVT. LTD.</td>
<td>(CS, &lt;=800#, SIZE ½-2, &lt;=300# FOR SIZE 2-6&quot;)</td>
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<td>23</td>
<td>INTERVALVE INDIA LTD.</td>
<td>(CAST UPTO 24&quot; (UPTO 300#) &amp; UPTO 12&quot; 600#, FORGED UPTO 2&quot; (800#))</td>
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<td>24</td>
<td>JC VALVES &amp; CONTROLS INDIA PVT. LTD.</td>
<td>(CAST UPTO 48&quot; (150#) &amp; 24&quot; (UPTO 600#) &amp; FORGED UPTO 2&quot; (800#))</td>
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<td>25</td>
<td>KIRLOSKAR BROTHERS LTD. (CS UPTO 12&quot;, 300#)</td>
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<td>26</td>
<td>KSB PUMPS LIMITED (VALVES DIVN)</td>
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<td>27</td>
<td>LARSEN &amp; TOUBRO LIMITED (1/2&quot; TO 24&quot;)</td>
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<td>28</td>
<td>LEADER VALVES LTD.</td>
<td>(Casting&lt;=20&quot;-600#, 300-150#, Forging&lt;=2&quot;-800#)</td>
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<td>29</td>
<td>M.H. VALVES PVT. LTD.</td>
<td>(1/2&quot; to 1 1/2&quot;-800#, 2&quot; to 6&quot;-600#)</td>
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<td>30</td>
<td>MICON ENGINEERS (HUBLI) [PVT. LTD.(Cast: Upto 12&quot; (150# &amp; 300#), 6&quot; (600#) &amp; Forged: upto 2&quot; (800#))</td>
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<td>31</td>
<td>MICROFINISH VALVES LTD.</td>
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<td>32</td>
<td>NSSL LTD.</td>
<td>(UPTO 80&quot; (150#), 56&quot; UPTO 600# &amp; FORGED UPTO 2&quot; (800#))</td>
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<td>NITON VALVES INDUSTRIES PVT. LTD.</td>
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<td>OSWAL IND. LTD.</td>
<td>(UPTO 48&quot; (150#), 32&quot; (300#) &amp; 24&quot; (600#))</td>
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<td>35</td>
<td>S &amp; M INDUSTRIAL VALVES LTD.</td>
<td>(CS Gate &amp; Globe Valves 2&quot; – 24&quot; &lt;=300#)</td>
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<td>36</td>
<td>SHALIMAR VALVES PVT. LTD.</td>
<td>(Cast Upto 24&quot; (Upto 600#), Forged: ½&quot; to 1 ½&quot; (800#))</td>
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<td>37</td>
<td>SHREERAJ INDUSTRIES (CS upto 150#)</td>
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<td>38</td>
<td>STEEL STRONGVALVES (I) PVT. LTD. (Upto 42&quot;)</td>
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<td>39</td>
<td>VENUS PUMP &amp; ENGINEERING WORKS.</td>
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<td>40</td>
<td>VIBA FLUID CONTROL</td>
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<tr>
<td>41</td>
<td>WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.)</td>
<td>(Cast UPTO 36&quot; (150#); 24&quot; (300#); 12&quot; (600#) &amp; Forged: Upto 2&quot; (800#))</td>
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<td>42</td>
<td>ZED VALVES CO. PVT. LTD.</td>
<td>(Upto 14&quot; (600#))</td>
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<td>43</td>
<td>ZOLOTO INDUSTRIES. (40 MM TO 200 MM(ONLY CS &amp; SS))</td>
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<td>44</td>
<td>VELAN INC. (UPTO 48”, 600#)</td>
<td>CANADA</td>
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<td>45</td>
<td>BOTELEI VALVE GROUP CO. LTD. (Cast Upto 56” (150#), 36” (300#), 24” (600#) &amp; Forged: Upto2” (800#))</td>
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<tr>
<td>46</td>
<td>ZHEJIANG JIEHUA VALVE CO. LTD.</td>
<td>CHINA</td>
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<td>47</td>
<td>PEMTO VALVE</td>
<td>GERMANY</td>
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<tr>
<td>48</td>
<td>CESARE BONETTI SPA (Cast Upto 42” (Upto 300#), 24” (600#) Forged: ½” to 1 ½” (800#))</td>
<td>ITALY</td>
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<tr>
<td>49</td>
<td>FASANI S.P.A.</td>
<td>ITALY</td>
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<td>FRIULCO SPA (UPTO 48” (150#), 32” (Upto 600#))</td>
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<td>51</td>
<td>GTC ITALIA, S.R.L.</td>
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<td>52</td>
<td>MANTOVANI SpA</td>
<td>ITALY</td>
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<td>53</td>
<td>OMB S.P.A.</td>
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<tr>
<td>54</td>
<td>PETROL VALVES S.R.L.</td>
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<td>55</td>
<td>MATSURA H. P MACHINE WORKS CO.LTD.</td>
<td>JAPAN</td>
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<tr>
<td>56</td>
<td>NISHITANI &amp; CO. LTD.</td>
<td>JAPAN</td>
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<tr>
<td>57</td>
<td>SOJITZ CORPORATION</td>
<td>JAPAN</td>
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<tr>
<td>58</td>
<td>REDPOINT ALLOYS BV</td>
<td>NETHERLAND</td>
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<td>59</td>
<td>WALTHAN &amp; WEIR</td>
<td>SPAIN</td>
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<tr>
<td>60</td>
<td>POYAM VALVES (AMPO S.CCP.) (Size upto 60” (Rating upto 800#))</td>
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<tr>
<td>61</td>
<td>BABCOCK BORSIG ESPANA , S.A</td>
<td>SPAIN</td>
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<td>62</td>
<td>SUFA LIMITED</td>
<td>U.A.E.</td>
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<td>63</td>
<td>BEL VALVES</td>
<td>U.K.</td>
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**GATE/ GLOBE/ CHECK VALVES CS/SS/AS > =900 LBS**

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<td>A V VALVES LIMITED (Cast Upto 24” (900# &amp; 1500#), 8” (2500#) Forged: Upto 2” (2500#))</td>
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<td>2</td>
<td>ADVANCE VALVES (2”-36” (900#) 2”-24” (1500#), 2”-12(2500#) Forged: Upto 2” (2500#)) FOR DUAL PLATE CHECK VALVES</td>
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<tr>
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<td>ASSOCIATED TOOLINGS (I) PVT. LTD. (½” TO 2” (900# &amp; 1500#))</td>
<td>INDIA</td>
</tr>
<tr>
<td>4</td>
<td>AUDCO INDIA LIMITED (L&amp;T VALVES DIVN.)</td>
<td>INDIA</td>
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<tr>
<td>5</td>
<td>BHEL (VALVES DIVISION)</td>
<td>INDIA</td>
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<td>6</td>
<td>FLOVEL VALVES PVT. LTD. (Dual Plate Check Valves: Upto 24” (900#))</td>
<td>INDIA</td>
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<td>7</td>
<td>HAWA ENGINEERS LTD. (Gate Valves: upto 20”(900#), upto 10” (1500# &amp; 2500#); Globe Valves: upto 8”( 900# &amp; 1500#), upto 1” (2500#); Check Valves: upto 10”(900#), upto 6” (1500#), upto 1” (2500#))</td>
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<td>HAWA VALVES INDIA PVT. LTD. (Forged upto 2”, 1500#)</td>
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<td>9</td>
<td>INTERVALVES INDIA LTD. (Forged: Upto 2” (1500#))</td>
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<td>Company Name and Details</td>
<td>Country</td>
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<td>JC VALVES &amp; CONTROLS INDIA PVT. LTD. (CAST UPTO 12&quot; (1500#), 10&quot; (2500#) &amp; FORGED UPTO 2&quot; (2500#))</td>
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<td>10</td>
<td>KSB PUMPS LIMITED (VALVES DIVN)</td>
<td>INDIA</td>
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<td>11</td>
<td>LARSEN &amp; TOUBRO LIMITED (1/2&quot; TO 2&quot;)</td>
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<td>LEADER VALVES LIMITED (1500# &amp; 2500# UPTO 12&quot;, FORGING UPTO 2&quot; 2500#)</td>
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<td>13</td>
<td>METROPOLITAN INDUSTRIES (SIZE=200mm, rating=2500 lb)</td>
<td>INDIA</td>
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<tr>
<td>14</td>
<td>MICON ENGINEERS (HUBLI) PVT. LTD. (FORGED: UPTO 2&quot; (1500#))</td>
<td>INDIA</td>
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<tr>
<td>15</td>
<td>NSSL LIMITED. (CAST: Upto 36&quot;(900#), 24&quot; (upto 2500#) &amp; FORGED: Upto 2&quot; (Upto 2500#))</td>
<td>INDIA</td>
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<td>16</td>
<td>OSWAL INDUSTRIES LTD. (Upto 12&quot; (900# &amp; 1500#))</td>
<td>INDIA</td>
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<td>17</td>
<td>SHALIMAR VALVES PVT.LTD.(CAST: UPTO 20&quot;(900#), FORGED: 1/2&quot; TO 1 1/2&quot; (1500#))</td>
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<td>18</td>
<td>WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Cast UPTO 12&quot; (upto 2500#) &amp; Forged: Upto 2&quot; (1500#), 1&quot; (2500#))</td>
<td>INDIA</td>
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<tr>
<td>19</td>
<td>VELAN INC. ( UPTO 24&quot; (Rating upto 2500#))</td>
<td>CANADA</td>
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<td>20</td>
<td>BOTELI VALVE GROUP CO. LTD.(Cast Upto 16&quot; (Upto 1500#), 12&quot; (2500#) &amp; Forged: Upto 2&quot; (1500# &amp; 2500#))</td>
<td>CHINA</td>
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<tr>
<td>21</td>
<td>ZHEJIANG JIEHUA VALVE CO. LTD.</td>
<td>CHINA</td>
</tr>
<tr>
<td>22</td>
<td>BFE BONNEY FORGE VALVE LICENSEE</td>
<td>ITALY</td>
</tr>
<tr>
<td>23</td>
<td>CESARE BONETTI SPA (Upto 24&quot; (Upto 2500#))</td>
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<td>24</td>
<td>FASANI S.P.A.</td>
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<tr>
<td>25</td>
<td>FRIULCO SPA (UPTO 32&quot; (900#); 24&quot; (1500#); 14&quot; (2500#))</td>
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<td>26</td>
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<td>27</td>
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<td>28</td>
<td>PETROL VALVES S.R.L.</td>
<td>ITALY</td>
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<td>29</td>
<td>VALVITALIA SPA</td>
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<td>30</td>
<td>MATSURA H. P MACHINE WORKS CO.LTD.</td>
<td>JAPAN</td>
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<td>31</td>
<td>NISHITANI &amp; CO. LTD.</td>
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<td>32</td>
<td>BABCOCK BORSIG ESPANA, S.A.</td>
<td>SPAIN</td>
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<tr>
<td>33</td>
<td>POYAM VALVES, (AMPO S. COOP.) (SIZE UPTO 30&quot; (RATING UPTO 2500#))</td>
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<tr>
<td>34</td>
<td>SUFA LIMITED</td>
<td>U.A.E.</td>
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<tr>
<td>35</td>
<td>BEL VALVES</td>
<td>U.K.</td>
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**BALL VALVES (SOFT SEATED)**

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<tr>
<th>No.</th>
<th>Company Name and Details</th>
<th>Country</th>
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<tbody>
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<td>1</td>
<td>A V VALVES LIMITED (Upto 12&quot; (Upto 600#))</td>
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<td>AQUA VALVES PVT. LTD.</td>
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<td>Description</td>
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<td>BRIGHTTECH VALVES &amp; CONTROLS PVT. LTD.</td>
<td>(4&quot; x 150# for CS, AS &amp; SS material)</td>
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<td>CHEMTECH INDUSTRIAL VALVES PVT. LTD.</td>
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<td>6</td>
<td>CRAWLEY &amp; RAY (FOUNDER &amp; ENGINEERS) PVT. LTD. (DN25)</td>
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<td>7</td>
<td>DELVAL FLOW CONTROLS PVT. LTD. (Upto 12&quot; (Upto 900#))</td>
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<td>8</td>
<td>FLOCON SYSTEMS PVT. LTD. (CS upto 6&quot;, 150#)</td>
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<td>9</td>
<td>FLOW CONTROL</td>
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<td>10</td>
<td>FLOWCHEM INDUSTRIES (UPTO 300# and upto 10&quot;)</td>
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<td>11</td>
<td>FLUIDTECH EQUIPMENT PVT. LTD (UPTO 4&quot; (300#))</td>
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<td>12</td>
<td>FORWARD ALLOYS AND CASTINGS (Upto 900#)</td>
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<td>13</td>
<td>GURU INDUSTRIAL VALVES PVT. LTD. (Cast Cs only: Upto 12&quot; (Upto 300#), 4&quot; (Upto 900#) &amp; Forged: Upto 2&quot; (800#))</td>
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<tr>
<td>14</td>
<td>HAWA ENGINEERS LTD. (Upto 16&quot; (150# &amp; 300#), Upto 12&quot; (600# &amp; 900#))</td>
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<td>15</td>
<td>INTERVALVE INDIA LTD. (Forged: Upto 2&quot; (800#), Cast: Upto 12&quot; (Upto 300#))</td>
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<td>16</td>
<td>JC VALVES &amp; CONTROLS INDIA PVT. LTD. (CAST UPTO 28&quot; (Upto 600#), 12&quot; (900#, 1500#) &amp; 10&quot; (2500#))</td>
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<td>17</td>
<td>KSB PUMPS LTD. (VALVES DIVN.) (CS upto 100DN, 20 bar)</td>
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<td>18</td>
<td>LEADER VALVES LTD. (Casting upto 600#, 6&quot; &amp; forging upto 800#, 2&quot;)</td>
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<td>19</td>
<td>MICON ENGINEERS (HUBLI) PVT. LTD. (Cast: Upto 6&quot; (150# &amp; 300#) &amp; Forged: Upto 2&quot; (800#))</td>
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<td>MICROFINISH VALVES (P) LTD.</td>
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<td>21</td>
<td>NSSL LTD. (Upto 12&quot; (150# &amp; 300#))</td>
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<td>22</td>
<td>OSWAL IND. LTD. (Upto 24&quot; (150#, 300# &amp; 600#))</td>
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<td>23</td>
<td>SHALIMAR VALVES PVT. LTD. (Upto 18&quot; (600#) Material: CS/AS/SS)</td>
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<td>24</td>
<td>VIBA FLUID CONTROL (Upto 300#)</td>
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<td>25</td>
<td>VIRGO ENGINEERS LTD. (Upto 16&quot; (upto 600#))</td>
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<td>26</td>
<td>WEIR BDK VALVES (Cast: Upto 30&quot; (150# &amp; 300#), 20&quot; (600#), 16&quot; (900#), 12&quot; (1500#) &amp; Forged: Upto 2&quot; (800#))</td>
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<td>XOMOX SANMAR LTD. (FISHER XOMOX)</td>
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<td>28</td>
<td>BHDT GMBH</td>
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<td>BOTELI VALVE GROUP CO. LTD. (Upto 32&quot; (150# &amp; 300#), 30&quot; (600#), 24&quot; (900#))</td>
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<td>ZHEJIANG JIEHUA VALVE CO. LTD.</td>
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<td>31</td>
<td>VELAN INC. (upto 16&quot;, 600#)</td>
<td>CANADA</td>
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<tr>
<td>32</td>
<td>ETS TROUVA &amp; CAUVIN</td>
<td>FRANCE</td>
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<td>33</td>
<td>PERRIN GMBH (2500#, size upto 24&quot;)</td>
<td>GERMANY</td>
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<td>34</td>
<td>FRIULCO SPA (upto 48&quot; (150# &amp; 300#); 20&quot; (upto 1500#); 12&quot; (2500#))</td>
<td>ITALY</td>
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<td>35</td>
<td>CESARE BONETTI SPA (cast: upto 4&quot; (150#) &amp; forged: upto 1&quot; (800#) floating only)</td>
<td>ITALY</td>
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<td>36</td>
<td>GTC ITALIA S.R.L</td>
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<td>37</td>
<td>MANTOVANUI SPA</td>
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<td>38</td>
<td>PIBIVESSE SRL (upto 48&quot;, 600#)</td>
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<td>39</td>
<td>PETROL VALVES S.R.L</td>
<td>ITALY</td>
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<td>40</td>
<td>METSO AUTOMATION</td>
<td>SINGAPORE</td>
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<tr>
<td>41</td>
<td>POYAM VALVES (AMPO S. COOP.) (size upto 42&quot; (rating upto 2500#))</td>
<td>SPAIN</td>
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<tr>
<td>42</td>
<td>HATIMA CORPORATION</td>
<td>TAIWAN</td>
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**BALL VALVES (METAL SEATED)**

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<tr>
<td>1</td>
<td>AIRA EURO AUTOMATION PVT. LTD. (upto 6&quot;, rating 150# &amp; 300#),</td>
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<td>2</td>
<td>BRIGHTTECH VALVES &amp; CONTROLS PVT. LTD. (4&quot; x 150# for CS, AS &amp; SS material)</td>
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<td>3</td>
<td>DELVAL FLOW CONTROLS PVT. LTD. (upto 12&quot; (upto 900#))</td>
<td>INDIA</td>
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<td>4</td>
<td>GURU INDUSTRIAL VALVES PVT. LTD. (cast CS only: upto 12&quot; (upto 300#), 4&quot; (upto 900#) &amp; forged: upto 2&quot; (800#))</td>
<td>INDIA</td>
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<td>5</td>
<td>HAWA ENGINEERS LTD. (upto 16&quot; (150# &amp; 300#), upto 12&quot; (600# &amp; 900#))</td>
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<td>6</td>
<td>INTERVALVE INDIA LTD. (upto 12&quot;, 150#).</td>
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<td>7</td>
<td>JC VALVES &amp; CONTROLS INDIA PVT. LTD. (cast up to 28&quot; (upto 600#), 12&quot; (upto 1500#), 10&quot; (2500#))</td>
<td>INDIA</td>
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<tr>
<td>8</td>
<td>MICON ENGINEERS (HUBLI) PVT. LTD. (cast: upto 6&quot; (150# &amp; 300#) &amp; forged: upto 2&quot; (800#))</td>
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<td>MICROFINISH VALVES (P) LTD.</td>
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<td>10</td>
<td>NSSL LIMITED (upto 12&quot; NB. (150# &amp; 300#))</td>
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<td>11</td>
<td>OSWAL INDUSTRIES LTD. (upto 24&quot; (150#, 300#, &amp; 600#))</td>
<td>INDIA</td>
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<td>12</td>
<td>VIRGO ENGINEERS LTD. (upto 16&quot; (upto 600#))</td>
<td>INDIA</td>
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<tr>
<td>13</td>
<td>WEIR BDK VALVES (a unit of WEIR INDIA PVT. LTD.) (cast: upto 30&quot; (150# &amp; 300#); 20&quot; (600#), 16&quot; (900#), 12&quot; (1500#) &amp; forged: upto 2&quot; (800#))</td>
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<tr>
<td>14</td>
<td>VELAN INC. (size upto 16&quot; (rating upto 600#))</td>
<td>CANADA</td>
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<tr>
<td>15</td>
<td>BOTELI VALVE GROUP CO. LTD. (upto 32&quot; (150# &amp; 300#), 30&quot; (600#), 24&quot; (900#))</td>
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<td>16</td>
<td>ALFA VALVOLE SRL</td>
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<td>17</td>
<td>CESARE BONETTI SPA (UPTO 24&quot; (150#) &amp; 4&quot; (UPTO 1500#) TRUNNION MOUNTED ONLY)</td>
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<td>GE POWER (NUOVO PIGNONE SPA)</td>
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<td>GTC ITALIA, S.R.L.</td>
<td>ITALY</td>
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<td>22</td>
<td>VALVITALIA SPA</td>
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<td>23</td>
<td>PERRIN GMBH (SIZE UPTO 24&quot; (RATING UPTO 2500#))</td>
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<td>24</td>
<td>RED POINT ALLOYS BV</td>
<td>NETHERLAND</td>
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<td>25</td>
<td>FRIULCO SPA (UPTO 48&quot; (150# &amp; 300#); 20&quot; (UPTO 1500#); 12&quot; (2500#))</td>
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<td>26</td>
<td>POYAM VALVES, (AMPO S. COOP.) (SIZE UPTO 42&quot; (RATING UPTO 2500#))</td>
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<td>27</td>
<td>METSO AUTOMATION</td>
<td>SINGAPORE</td>
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<tr>
<td>28</td>
<td>ORBIT VALVES PLC</td>
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**BUTTERFLY VALVES**

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<td>A V VALVES LIMITED (UPTO 48&quot; (150#))</td>
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<td>ADVANCE VALVES (RUBBER LINED AND METAL SEATED)</td>
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<td>AIRA EURO AUTOMATION PVT. LTD. (Upto 48&quot;, Rating upto 300#)</td>
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<tr>
<td>4</td>
<td>AUDCO INDIA LIMITED (L&amp;T VALVE DIVN.)</td>
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<td>5</td>
<td>BDK PROCESS CONTROL PVT LTD. (UPTO 1600MM)</td>
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<td>CHEMTECH INDUSTRIAL VALVES PV LTD</td>
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<td>CRAWLEY &amp; RAY (FOUNDER &amp; ENGINEERS) PVT. LTD. (40mm-1000mm)</td>
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<td>DELVAL FLOW CONTROLS PVT. LTD. (Upto 24&quot; (Upto 300#))</td>
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<td>9</td>
<td>FLOCON SYSTEMS PVT. LTD. (CS upto 12&quot;, 150#)</td>
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<td>10</td>
<td>FLUIDTECH EQUIPMENT PVT. LTD. (CS upto 12&quot; (300#))</td>
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<td>FOURESS ENGINEERING (I) LTD.</td>
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<td>HAWA ENGINEERS LTD. (2&quot; to 48&quot;(PN10/PN16/150#/300#))</td>
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<td>HAWA VALVES INDIA PVT. LTD. (CS UPTO 6&quot;, 150#)</td>
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<td>HI-TECH BUTTERFLY VALVES INDIA PVT. LTD (&lt;300#, &lt;30&quot;(TEFLON/RUBBER), &lt;72&quot;(METAL))</td>
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<td>JC VALVES &amp; CONTROLS INDIA PVT. LTD. (Upto 20&quot; (150#) &amp; 10&quot; (300#))</td>
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<tr>
<td>No.</td>
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<td>L&amp;T LTD (1/2&quot; TO 24&quot;)</td>
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<td>LEADER VALVES LTD.(150#, upto 16&quot;)</td>
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<td>20</td>
<td>MATHER &amp; PLATT (INDIA) LTD. A SUBSIDIARY OF WILO SE GERMAN (UPTO DN 1600,PN10, Double flange type)</td>
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<td>METROPOLITAN INDUSTRIES (SIZE=2000mm)</td>
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<td>MICON ENGINEERS (HUBLI) (PVT. LTD. (Upto 24” (PN10 &amp; PN16))</td>
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<td>23</td>
<td>VENUS PUMP &amp; ENGINEERING WORKS (upto 600NB, 150#)</td>
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<td>VIRGO ENGINEERS LTD. ((Triple offset only): 3” to 24”, Upto 600# (CS/SS))</td>
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<td>WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 56” (Upto 250#), 24” (300#))</td>
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<td>XOMOX SANMAR LIMITED (FISHER XOMOX)</td>
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<td>TOMOE VALVE CO. LTD. (Upto 48”(150# &amp; 300#), Upto 24”(600#, 900# &amp; 1500#))</td>
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<td>BHDT GMBH</td>
<td>AUSTRIA</td>
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<td>VELAN INC. (Size upto 48”(Rating upto 600#)</td>
<td>CANADA</td>
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<td>BOTELI VALVE GROUP CO. LTD. (Upto 36” (150# &amp; 300#))</td>
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<td>GRISS SAPAG INDUSTRIAL VALVES</td>
<td>FRANCE</td>
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<td>33</td>
<td>ADAMS ARMATUREN</td>
<td>GERMANY</td>
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<td>34</td>
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<td>ITALY</td>
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<td>WEIR VALVES &amp; CONTROLS DIVISION.</td>
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<td>TYCO INTERNATIONAL INC.,U.S.A.</td>
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<td>XOMOS (CRANE CO.)</td>
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**PLUG VALVES (NON LUBRICATED)**

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<th>Country</th>
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<td>A V VALVES LIMITED (UPTO 48&quot; (150#))</td>
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<td>2</td>
<td>AUDCO INDIA LTD (L&amp;T VALVES DIVN.)</td>
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<td>3</td>
<td>AZ ARMATUREN GMBH (1/2&quot; TO 20&quot;(150#, 300# &amp; 600#), Matl. CS, AS &amp;SS)</td>
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<td>4</td>
<td>BDK PROCESS CONTROL PVT LTD.</td>
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<td>5</td>
<td>CHEMTECH INDUSTRIAL VALVES PVT LTD</td>
<td>INDIA</td>
</tr>
<tr>
<td>No.</td>
<td>Vendor Name</td>
<td>Country</td>
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<td>6</td>
<td>CRAWLEY &amp; RAY (FOUNDRERS &amp; ENGINEERS) PVT. LTD (DN 200)</td>
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<tr>
<td>7</td>
<td>FLUIDTECH EQUIPMENT PVT. LTD. (Upto 4” (300#))</td>
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<td>8</td>
<td>GURU INDUSTRIAL VALVES PVT. LTD. (Cast CS only: Upto 12” (Upto 300#), Upto 4” (Upto 900#)) &amp; Forged: Upto 2” (800#))</td>
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<tr>
<td>9</td>
<td>HAWA ENGINEERS LTD. (1/2” TO 8” (150#))</td>
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<td>10</td>
<td>JC VALVES &amp; CONTROLS INDIA PVT. LTD. (Upto 12” (Upto 300#))</td>
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<td>11</td>
<td>L&amp;T LTD ( 1/2” TO 24”)</td>
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<td>12</td>
<td>LEADER VALVES LIMITED (Upto 6” (Upto 300#))</td>
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<td>13</td>
<td>WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (UPTO 16”(150#), 12” (300#), 3” (600#))</td>
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<tr>
<td>14</td>
<td>XOMOX SANMAR LIMITED (FISHER XOMOX)</td>
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<tr>
<td>15</td>
<td>ZHEJIANG JIEHUA VALVE CO. LTD.</td>
<td>CHINA</td>
</tr>
<tr>
<td>16</td>
<td>O.M.S. SALERI DI SALERI P &amp; FIGLI S.M.C.</td>
<td>ITALY</td>
</tr>
<tr>
<td>17</td>
<td>POYAM VALVES, (AMPO S. COOP.) (UPTO 30” (UPTO 900#) FOR LIFT PLUG VALVES ONLY.)</td>
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**Flat Gaskets**

<table>
<thead>
<tr>
<th>No.</th>
<th>Vendor Name</th>
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<tbody>
<tr>
<td>1</td>
<td>FERROLITE JOININGS (P) LTD.</td>
<td>INDIA</td>
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<tr>
<td>2</td>
<td>GASKETS (INDIA) PVT. LTD.</td>
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<tr>
<td>3</td>
<td>GOODRICH GASKET PVT. LTD. (UPTO 24”)</td>
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<tr>
<td>4</td>
<td>HINDUSTAN ASBESTOS &amp; ALLIED PRODUCTS</td>
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<tr>
<td>5</td>
<td>HINDUSTAN COMPOSITE LTD.</td>
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<td>6</td>
<td>HINDUSTAN FERREDO LTD.</td>
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<td>7</td>
<td>IGP ENGINEERS LIMITED</td>
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<tr>
<td>8</td>
<td>MADRAS INDUSTRIAL PRODUCTS(UPTO 48”)</td>
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<td>9</td>
<td>MECHANICAL PACKING INDUSTRIES LTD.</td>
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<tr>
<td>10</td>
<td>PACKING &amp; JOINTINGS (P) LTD.</td>
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<tr>
<td>11</td>
<td>PERFECT MARKETING (P) LTD.</td>
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<tr>
<td>12</td>
<td>PRASHANT ENGG STORES</td>
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<tr>
<td>13</td>
<td>REIN TALBROS PVT. LTD.</td>
<td>INDIA</td>
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<tr>
<td>14</td>
<td>SPIRALSEAL GASKETS PVT. LTD. (CAF &amp; Teflon)</td>
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<tr>
<td>15</td>
<td>STARFLEX SEALING INDIA PVT. LTD.</td>
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<tr>
<td>16</td>
<td>THE BENGAL MILL STORES SUPPLY CO. (TRADER)</td>
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<tr>
<td>17</td>
<td>UNIQUE INDUSTRIAL PACKINGS PVT. LTD.</td>
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**Spirally Wound Gaskets**

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<td>GASKETS (INDIA) PVT. LTD.</td>
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<td>2</td>
<td>GOODRICH GASKET PVT. LTD.</td>
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<tr>
<td>3</td>
<td>IGP ENGINEERS LIMITED</td>
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<td>4</td>
<td>MADRAS INDUSTRIAL PRODUCTS</td>
<td>INDIA</td>
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<tr>
<td>Number</td>
<td>Company Name</td>
<td>Country</td>
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<tr>
<td>5</td>
<td>PACKINGS &amp; JOINTINGS PVT. LTD</td>
<td>INDIA</td>
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<tr>
<td>6</td>
<td>PERFECT MARKETING (P) LTD,</td>
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<td>7</td>
<td>PRASHANT ENGG STORES</td>
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<td>8</td>
<td>SPIRASEAL GASKETS PVT. LTD.</td>
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<td>STARFLEX SEALING INDIA PVT. LTD.</td>
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<td>10</td>
<td>THE BENGAL MILL STORES SUPPLY CO. (TRADER)</td>
<td>INDIA</td>
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<tr>
<td>11</td>
<td>UNIQUE INDUSTRIAL PACKINGS PVT.LTD. (UPTO 42&quot;(600#) &amp; UPTO 24&quot; (2500#))</td>
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<tr>
<td>12</td>
<td>ZHEJIANG JIEHUA VALVE CO. LTD.</td>
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**EXPANSION JOINTS & BELLOWS**

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<th>Number</th>
<th>Company Name</th>
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<tr>
<td>1</td>
<td>CORI ENGINEERS PVT. LTD.</td>
<td>INDIA</td>
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<tr>
<td>2</td>
<td>D.WREN &amp; CO. (For Rubber &amp; Fabric)</td>
<td>INDIA</td>
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<tr>
<td>3</td>
<td>FLEXATHERM EXPANLLOW PVT. LTD. (Circular: Upto 240&quot;, Rectangular No bar for size, (Upto 600#))</td>
<td>INDIA</td>
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<tr>
<td>4</td>
<td>FLEXICAN BELLOWS &amp; HOSES PVT. LTD</td>
<td>INDIA</td>
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<td>5</td>
<td>FLUIDYNE ENGG. (I) PVT. LTD</td>
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<td>6</td>
<td>KELD ELLENTOFT INDIA PVT. LTD</td>
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<td>7</td>
<td>LONESTAR INDUSTRIES</td>
<td>INDIA</td>
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<td>8</td>
<td>MB METALLIC BELLOWS (INDIA) PVT. LTD</td>
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<td>9</td>
<td>PRASHANT ENGG. STORES</td>
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<td>10</td>
<td>STANDARD PRECISION BELLOWS</td>
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<td>11</td>
<td>TUBOFLEX</td>
<td>GERMANY</td>
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<td>12</td>
<td>FLEXIDER S.P.A.</td>
<td>ITALY</td>
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**STRAINERS (PERMANENT INCLUDING Y-TYPE)**

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<th>Number</th>
<th>Company Name</th>
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<tr>
<td>1</td>
<td>CHEMTECH INDUSTRIAL VALVES PVT. LTD</td>
<td>INDIA</td>
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<tr>
<td>2</td>
<td>FLAIR STRAINERS &amp; FILTERS (SIZE UPTO 42&quot; (RATING UPTO 1500#))</td>
<td>INDIA</td>
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<tr>
<td>3</td>
<td>GRAND PRIX ENGINEERING PVT. LTD. (UPTO 60&quot; PIPELINE, UPTO ANSI 1500#)</td>
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<tr>
<td>4</td>
<td>GREAVES LIMITED</td>
<td>INDIA</td>
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<td>GUJARAT OTOFILT</td>
<td>INDIA</td>
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<td>HAWA ENGINEERS LTD. (1/2&quot; to 24&quot;(150# / 300#)</td>
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<td>KWIKFLO FILTERS PVT. LTD.</td>
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<td>LEADER VALVES LTD. (upto 300# &amp; upto 12&quot; size)</td>
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<td>MULTITEX FILTERATION ENGINEERS LTD</td>
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<td>MOD FABRICATORS</td>
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<td>11</td>
<td>ZOLOTO INDUSTRIES (15MM TO 100MM)</td>
<td>INDIA</td>
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<td>Vendor Name</td>
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<td>12</td>
<td>Boteli Valve Group Co. Ltd. (Y - Type Only: 14&quot; (150#) &amp; 3&quot; (300# &amp; 600#))</td>
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<td><strong>STEAM TRAPS</strong></td>
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<td>2</td>
<td>Pennant Engineering Pvt. Ltd.</td>
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<td>3</td>
<td>Virgo Engineers Ltd. (1/2&quot; to 4&quot; (upto 600#) (CS/SS))</td>
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<td>4</td>
<td>Yarway Corporation</td>
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<td>5</td>
<td>Zoolo Industries (15 mm to 25 mm)</td>
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<td>6</td>
<td>Gestra AG</td>
<td>Germany</td>
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<td>7</td>
<td>Armstrong International Inc.</td>
<td>U.S.A</td>
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<td>8</td>
<td>Ogotz Corporation</td>
<td>U.S.A</td>
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<tr>
<td>9</td>
<td>Tyco International Inc., U.S.A.</td>
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<td><strong>SPRING SUPPORTS</strong></td>
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<td>Myrics Piping System Pvt. Ltd.</td>
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<td>2</td>
<td>Pipe Supports India Pvt. Ltd.</td>
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<td>3</td>
<td>Piping &amp; Energy Products (P) Ltd.</td>
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<td>4</td>
<td>Sarathi Engg. Enterprises Pvt. Ltd.</td>
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<td>5</td>
<td>Spring Supports Mfg. Co.</td>
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<td>Flexider S.P.A.</td>
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<td><strong>FASTENERS</strong></td>
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<td>Capital Industries</td>
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<td>3</td>
<td>Console Engg. &amp; Fastners Industries</td>
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<td>4</td>
<td>Eby Fastners</td>
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<td>5</td>
<td>Fit Tight Nuts &amp; Bolts Ltd.</td>
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<td>6</td>
<td>Fix Fit Fasteners Mfg. Pvt. Ltd.</td>
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<tr>
<td>7</td>
<td>Industrial Engineering Corporation (Size Upto 4&quot; (M100))</td>
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<td>8</td>
<td>MEGA Engineering Private Limited (½&quot; TO 3&quot; MATERIAL: CS/AS/SS)</td>
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<td>9</td>
<td>Metro Mechanical Pvt. Ltd.</td>
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<td>Nagbhushanam Industries</td>
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<td>11</td>
<td>Nireka Engg. Co. Pvt. Ltd.</td>
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<td>12</td>
<td>Pacific Forging &amp; Fasteners Pvt. Ltd. (M 10 TO M125)</td>
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<td>13</td>
<td>Perfect Marketing (P) Ltd.</td>
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<td>Pioneer Nuts &amp; Bolts Pvt. Ltd.</td>
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<td>15</td>
<td>Precision Auto Engineers</td>
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<td>16</td>
<td>PRECISION ENGINEERING INDUSTRIES</td>
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<td>PTD FASTNERS PVT. LTD.</td>
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<td>18</td>
<td>SANGHVI METALS (TRADER)</td>
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<td>19</td>
<td>SUNDARAM FASTENERS LIMITED</td>
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<tr>
<td>20</td>
<td>UDHERA FASTENERS</td>
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**FIRE FIGHTING SYSTEM**

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<td>AGNICE FIRE PROTECTION LTD.</td>
<td>INDIA</td>
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<tr>
<td>2</td>
<td>BHARTIYA CACCIALANZA FIRE SYSTEMS LTD.</td>
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<tr>
<td>3</td>
<td>BLUE STAR LTD.</td>
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<tr>
<td>4</td>
<td>DE'S TECHNICO</td>
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<td>5</td>
<td>DE'S TECHNICO PVT. LTD.</td>
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<td>6</td>
<td>FUTECH CONSULTANTS PVT. LTD.</td>
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<td>GENERAL MECHANICAL WORKS</td>
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<td>9</td>
<td>LAL ENTERPRISES</td>
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<tr>
<td>10</td>
<td>MATHER &amp; PLATT (INDIA) LTD. (A Subsidiary of WILO SE German)</td>
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<td>11</td>
<td>MX SYSTEMS INTERNATIONAL PVT. LTD.</td>
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<td>12</td>
<td>NEWFIRE ENGINEERS SERVICES</td>
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<td>13</td>
<td>PRAGATI ENGG. (PVT.) LTD.</td>
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<td>PYROTEK INDUSTRIES (INDIA) PVT. LTD.</td>
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<td>RADIANT FIRE PROTECTION ENGINEERS</td>
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<td>STEELAGE INDUSTRIES LTD.</td>
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<td>TECHNOFAB ENGG.</td>
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<td>TRI-PARULEX FIRE PROTECTION SYSTEMS</td>
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<td>19</td>
<td>UNITECH MACHINES LTD</td>
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<td>20</td>
<td>VIJAY FIRE PROTECTION SYSTEM LTD.</td>
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**HOSE PIPE (METALLIC) & CAM LOCK COUPLING**

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<tr>
<td>1</td>
<td>AEROFLEX INDUSTRIES LIMITED (Size 6mm to 250mm dia. (SS Corrg. Flex. Hose with Braid, Braid &amp; Assembly)</td>
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<tr>
<td>2</td>
<td>CHHATARIA RUBBER CHEMICALS INDUSTRIES</td>
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<td>3</td>
<td>D. WREN &amp; CO.</td>
<td>INDIA</td>
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<tr>
<td>4</td>
<td>FLEXATHERM EXPANLLOW PVT. LTD. (1/2” to 6”)</td>
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<td>5</td>
<td>GAYATRI INDUSTRIES</td>
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<td>6</td>
<td>GAYATRI INDUSTRIAL CORPORATION (UPTO 6” ID)</td>
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<td>7</td>
<td>HELIFEX HYDRAULICS &amp; ENGG CO. LTD.</td>
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<tr>
<td>8</td>
<td>SENIOR INDIA PVT. LTD.</td>
<td>INDIA</td>
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</tbody>
</table>
NOTE:

1. Bidder to note that above vendor list enclosed with the NIT shall only be followed by bidder. Any additional vendor list furnished by bidder along with bid shall not be considered.
2. LSTK contractor shall evaluate and decide present financial, performance credential and shop loading conditions of the above vendors before placement of enquiry/orders.
3. Make of the equipment/machinery/item, not indicated shall be subject to Owner’s / Consultant’s approval.
4. Vendor List shall be prepared by Bidder for equipment/machinery/item not covered in above Vendor List. While submitting the additional vendor list, bidder has to ensure the following points.
   - As it is not possible to ascertain credentials of all the added vendors by Bidders by Owner, with regard to the additional vendors proposed by Bidder, following prequalification criteria, with respect to Past Performance / Experience for any Equipment/item shall be applicable:
     - The Vendor during the last 15 (fifteen) years, should have designed, manufactured (under third party inspection agencies like Lloyds Register/TUV/BVIS) and supplied at least TWO similar Plant Equipment or Machinery or Item for similar duties and operating conditions and same should be operating satisfactorily after installation for at least TWO years.

   The LSTK Bidder should satisfy themselves that sufficient documentary proof is submitted such as:
   a. Copy of Purchase Orders with full technical details of the equipment
   b. Certificate from user regarding satisfactory performance.
   c. Accreditation from third party inspection agencies like Lloyds Register, TUV, BVIS.
   d. Availability of After Sales Service and Spares in India.
   e. Availability of ASME Certification and its validity.

   All documents (PTR) shall be in English language only.

   The LSTK Bidder shall certify suitability of such vendors as per above.

Vendor for these equipment/machinery/item shall be finalized during detail engineering stage upon mutually agreed condition between bidder & Owner/Consultant.